Indian Journal of Physical Medicine & Rehabilitation

IJPMR April 2006; 17 (1)

Editorial

Neural Prosthesis – Past, Present and Future

Damage to the central nervous system and its component architecture is a major cause of disability amongst humans. Physiatrists are often dealing with problems associated with acceptance and use of conventional orthoses and prostheses. Most common cause for rejection turns out to be frustration amongst patients for being unable to control the aids as desired by the person. Hence the idea of thought controlled appliances, and other voluntary / involuntary control mechanisms became an important area of development and many advancements have been occurring. Currently, many approaches for restoring the connectivity of neural elements are being explored (e.g., gene therapies, stem cell transplants, tissue engineering). One of the highly promising parallel areas developing is neural prosthesis engineering, which can provide the patients an alternative approach to restore functions through the building of suitable interfaces with the nervous system. Hence it is important that the physiatrists are in tune with the technological developments in the field of neural prosthesis engineering so that such techniques can be implemented for better rehabilitation of the patients.

The design of a neuro-prosthesis emulates the physiology of nervous system integrated with knowledge of microelectronics and computer sciences. The design challenges include signal measurement using electrodes without affecting the body system, signal interpretation with respect to correlation of measured neural signal and intended action, intent interpretation for creating responses to certain problems, performing the desired action, signal generation to achieve a specified goal, signal transmission without causing displacement, overcoming irritation and other problems, and achieving of optimal functionality .

Since 1957 - when the first neural prosthesis i.e. cochlear implant was developed - there has been a vast development in this field. The landmarks include development of internal pacemaker (1958), first motor prosthesis for foot drop in hemiplegics (1961), first auditory brainstem implant (1977), peripheral nerve bridge implanted into spinal cord of adult rat (1981) etc. In the 1980's and 90's there were extensive developments in the field of neural prosthetics wherein the fruits of research were tested with the patients and were successfully prescribed. During 1986-1995, trials proved FES (Functional Electrical Stimulation) allowed paraplegics to walk and in 1988 lumbar anterior root implant was developed for facilitating standing. In 1995 human trials began for foot drop splint, and for bionic glove and visual cortex prosthesis. FDA has by now approved many devices for application on humans after successful trials. Some of these are freehand system for quadriplegics, transcutaneous neurostimulation of 3rd and 4th sacral nerves to treat urinary incontinence, auditory brainstem implant for human use, vagal nerve stimulator. FDA authorized optobionics to begin trials of Artificial Silicon Retina (ASR) in sub-retinal implant, ACTIVA tremor control therapy technology (deep brain stimulation) to treat parkinsonism, implantation of Abio Cor, a permanent self contained total heart replacement, hand master system etc. Presently there is advanced ongoing research in the area of thought controlled prosthesis and more compatible biomaterials for implantation into human body e.g. microelectrode arrays, IST (Implanted Stimulator Telemeters), IJAT (Implanted Joint Angle Transducers), intradural electrodes for walking in paraplegics etc.

Some other newer clinical applications & technologies which hold promise for the future are potential use of electricity to aid in neural regeneration; BION System with RF (Radio-Frequency) link (small injectable single channel stimulator) – used in hemiplegia for shoulder subluxation; biofuel cells (these cells make use of body's own chemistry and structure) with introduction of special components to generate power, control from motor and pre-motor areas of brain for applications in controlling robotic arm etc. Promising areas of future research are improvements in thought controlled motion, biocompatibility and human implantation technology, ways of allowing cortical signals to control functional movement as well as system state (e.g. turning the system on/off, or exercising the states) etc. With the above mentioned technological advances taking place across the developed world, it is important that rehabilitation specialists in developing countries not only be abreast with the advancements, but also initiate collaborative efforts with key technological institutes to further contribute to this field, and prepare to use the increasingly innovative approaches for better rehabilitation and training of persons with disability. The abilities that technological strides can infuse into human functioning through judicious man-machine interaction are set to transcend newer frontiers and rehabilitation medicine is ideally positioned to guide the transformation process.

Dr Gita Handa
MBBS, MD (PMR)
Assistant Editor
Assistant Professor
Department of PMR
AIIMS, New Delhi 110029