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Review Article

Neuroplasticity and Prosthodontic Treatment-A Narrative Review

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Abstract

Neuroplasticity is a recently evolved branch of science though its roots can be traced back to 20th century. This science has established the fact that in extreme experiential situations, the brain develops a potential to undergo functional changes which may compensate for impaired brain functions. There are two branches for neuroplasticity viz. structural neuroplasticity and functional neuroplasticity. The former indicates the change that happens between neurons. The latter describes the permanent change that happens in the synapses. Neuroplasticity has found applications with many branches of health science. Dentistry is no exception for this. Use of dentures in the beginning is a tough task but later it becomes an easy practice. It is one of the finest examples of neuroplasticity and the changes it causes to the brain. This review briefly narrates the recently explored facts of neuroplasticity. The world of dentistry finds new meanings in explaining the functions in the context of neuroplasticity.

Keywords: Neuroplasticity; Neural Connections; Reorganization of the Brain; Synapses; Structural Neuroplasticity; Functional Neuroplasticity

Introduction

Brain can change its structure and function when it is subjected to new experiences and challenges. This phenomenon is known as neuroplasticity or brain plasticity. To be precise, it is the capacity of the nerve tissue to make new inter-neuronal connections or synapses. With this process nonfunctional neurons will be replaced with new neurons. Neuroplasticity can reorganize the functions and can readapt them.

Formerly it was thought that the brain development happens only during the childhood and the connections of the brain cells remain fixed when an individual grows old. Young brains were considered to have plasticity and have the capacity to make new connections. This character of neuroplasticity was thought to be present only in the young and not in the adults. Hence the healing capacity of the brain in the adults was thought to be absent. Only in the second half of the 20th century, studies have come up with evidence that adult brains also have plasticity. Comparatively, neuroplasticity in adults is lesser than that in the children. Plasticity is related to healthy development of the brain, learning, memory and brain damage repair [1,2].

Neurons are the basic, fundamental units of the nervous system. It has a body that contains the nucleus, dendrites that can receive signals and an axon through which signals can be transmitted to other connected neurons. The connecting system is known as synapses or the junction between neurons through which signals are transmitted by chemicals or it can be electrical. The protoplasm of the neurons does not mix and in fact they are separated by a gap but the nerve impulses, either chemical or electrical can cross the gap [3,4].

The old belief of neural system was that 'everything may die and nothing may be regenerated' does not fit into the new concepts evolved after 1998. Now it is proved that new neurons will be developed in the adult brain and the existing neurons can develop new branches. Even though the basic synaptic pattern between centres in an individual is dictated by the genetic programme, neural circuits and pathways get modified throughout the life and that is the basis of neural plasticity [5,6].

History of neuroplasticity

The theory behind the brain's ability to change for the purpose of adapting to newer situations was first suggested by William James in his work on 'Principles of psychology'. Polish neuroscientist Jerzy Konorski defined the phenomenon in his book 'Conditioned reflexes and neuron organisation' as neuroplasticity (Figure 1,2). [7,8]. In 1972, neuroplasticity was demonstrated on actual cases and proved that healthy regions of brain can take over the functions of the injured or damaged parts of the brain [9]. Later studies were conducted for the treatment of hemiplegia and learning difficulties using the principles of neuroplasticity. The developments on neuroplasticity did not have a smooth progression and in fact it faced stiff resistance from the academics until the beginning of the present century. Articles on neuroplasticity started appearing only very recently especially those related to oral health [10].

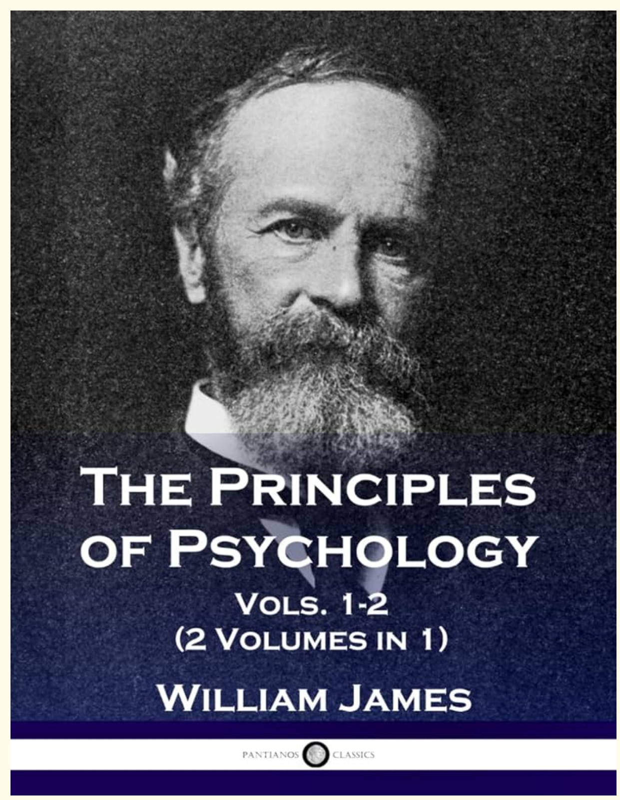

Figure 1: William James - Principles of Psycology.

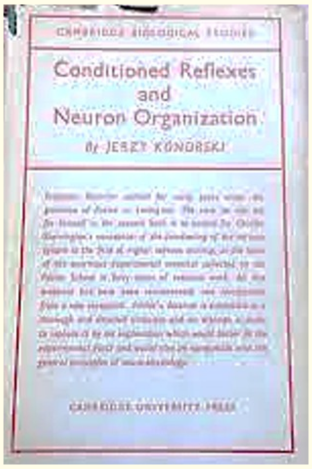

Figure 2: J Konorski -Conditioned reflexes.

How does neuroplasticity work

During the first few years of the child, there is a rapid growth of the brain. At birth every neuron has an estimated 2500 synapses (Figure 3). By the age of three the number grows to 15000. During the adulthood, this number gets halved. Because of the newer experiences, some connections get strengthened and some which are not made use of gets eliminated. This is known as synaptic pruning. This is the method by which the brain gets adapted to changing situations. Neuroplasticity helps to learn new things and enhances cognitive capabilities. Recovery from strokes and trauma is made possible because of neuroplasticity. Young brains are more sensitive and responsive to experiences compared to those of the adult brains. Adult brains can also respond to changing situations and adapt but not in all areas [11].

Improvement in neuroplasticity

During the younger age, brain should be given adequate opportunities of challenging nature and which has stimulatory potential. Environment provided during the younger days usually benefits the adulthood also. Reading, learning a language, learning to play a musical instrument and adequate rest give a stimulatory environment and improves brain plasticity. Playing video games, incorporating virtual reality, undergoing yoga practices and meditation have positive effects in improving neuroplasticity. Life style that includes regular exercise prevents loss of neurons and it has been proved that memory improves with exercise [12,13].

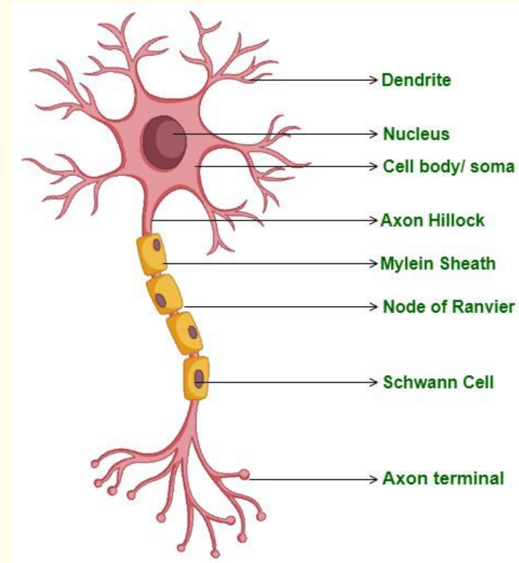

Figure 3: Neuron-structure.

Effect of tooth loss on the brain

Teeth and different organs of the body are connected with neural net work which provide sensory reception as well as proprioception. Tooth loss cause many functional impairments with regards to mastication, speech, proprioception and stereognosis. A loss of six teeth has caused mental health impairments like anxiety and depression [14,15]. MRI investigations have established a connection between loss of teeth and volumetric changes in the brain, specifically in the Gray matter. This can cause a reduction in the functions of tongue and jaw [16]. Patients with Parkinson's disease suffer from tooth loss and it has been estimated that in an average of 13 teeth are lost where as in individuals without parkinson's disease the number comes down to 9 [17]. However, it has to be established whether restorative treatment can bring back the nerve conduction potential [18].

Denture wearer and neuroplasticity

As part of a study, denture wearers were selected who reported for continued treatment of pain and discomfort. The occlusal contact area and the masticatory force exerted were measured before and after providing the treatment. Their neuronal function was also evaluated using established diagnostic method of neuronal dysfunction (DIMENSION). This testing included EEG measurements which records the electrical activity of the brain. Denture wearers who were suffering from Alzheimer's disease were excluded from the study. Execution of prosthodontic treatment related to dentures, mainly resulted in pain relief and reduction of discomfort and corresponding brain function activation was also noticed. The follow up treatment for pain relief and poor fit has caused improvement in occlusal contact area and occlusal force. EEG results endorsed improved brain activity. The brain function activation was also significantly improved with the use of dentures. Sensory information provided through trigeminal nerve involving periodontal ligament, masticatory muscles, TMJ and residual mucosa increased considerably along with chewing comfort. The above findings stand testimony to the fact that, use of dentures not only improves mastication, but they can enhance brain functions too [19,20].

How neuroplasticity benefits a new denture wearer during mastication

Changes in the oral environment, caused because of the tooth loss and subsequent restorative replacements provided can initiate neuroplastic adaptations in the brain which can modify both sensory and motor functions. When patients are treated with prosthesis with either tissue, tooth or implant support, the sensory and motor inputs generated can change oral functions and can optimise mastication. In fact, the brain activity related to chewing improves and this is considered as neuroplastic activity. With the newly identified capability of neuroplasticity, stereognostic abilities have improved with implant treatment also. Once it was considered as an impractical suggestion because of the loss of periodontal ligaments with implant treatment. There are recent evidences which prove that proprioception is possible with Osseo integrated dental implants. The conventional arguments for timely use of replacement dentures are still valid but a new profile is added and that is the role of teeth in obtaining optimum neurological function [21].

Oral health and brain health

Oral health status of an individual reflects the health status of the brain. Studies have shown that there is a link between periodontal disease and the early progression of Alzheimer's disease. Periodontal disease causes higher levels of microorganisms in the blood stream which deteriorates the brain health. This happens with any type of cognitive disease and results in the loss of memory. Tooth loss and gum disease can affect the neuroplasticity status and can cause emotional fluctuations. The microorganisms from the periodontal disease can cause systemic inflammation and disrupts brain function including the neuroplasticity. Personal and professional dental care can help mitigate potential negative effects on brain health [22].

Neuroplastic prosthodontics

Orofacial tissues and particularly the teeth have high tactile sensibility and special localising ability because of the dense innervation. Jaw position, movement and occlusal loading are identified by the proprioceptive innervation of the periodontal ligament. However, the muscles do not have such sophisticated proprioceptive innervation [23-25]. The functional ability of natural teeth and that of prosthesis do not really match. Denture wearers always feel the superior nature of natural teeth which they have experienced once. As age advances, individuals lose the ability to detect innocuous and noxious stimuli and hence the teeth are not protected against overloading. Chewing efficiency also gets reduced and as far as possible natural teeth elements are preserved, as in over dentures, to improve the chewing quality. If natural teeth elements are not preserved and if prostheses are indicated, neuroplastic prosthesis might play an important role. In fact, any type of dental treatment can induce neuroplasticity ie. sensory and motor alterations. When teeth are lost, the neuronal inputs are restricted. Providing a prosthesis, to some extent improves function or at least restricts functional deterioration. The replacement dentures provide an avenue to maintain neuronal connections through neuroplasticity [26]. The neuroplastic mechanism is influenced by past experiences and ongoing repetitions. However, in older individuals, the adaptive capacity which is the core of neuroplasticity will be diminished considerably. Prosthodontist who understands the principles of neuroplasticity can provide adequate education to the patient in relation to the treatment and which can be advantageous to the patient in gaining sensory-motor skills [27].

Implants and neuroplasticity

Neuroplasticity requires a well structured neural network to get the advantage of neuroplasticity. Successful dental implants are anchored to the bone by a well established phenomenon of osseointegration. Periodontal ligaments are missing for the implants but the central nervous system gets sensory feed back through a process of Osseo perception. Studies have indicated that force application to implants could elicit proprioceptive response. The mechanism of Osseo perception is a highly debated issue. One logical explanation is that peri-implant bone contains nerve fibres which may serve as valid source of sensory response. Compression or elongation can cause changes in the cytostructure of the osteocytes and which can activate the nerve endings present in the bone [28-31].

Dental implant, when it makes a direct contact to the bone can elicit different responses which includes neuroplasticity. While placing the implant, mechanical stresses are generated which can activate the glial cells and can provide structural support to the neurons. Glial cells play a vital role in the formation and pruning of synapses. Glial cells can provide nutritional support to the neurons. Possibly this is how neuroplasticity is initiated by the implants [32].

Implant treatment procedures were subjected to modifications, possibly in the context of neuroplasticity. Atraumatic tooth extraction which has become a popular implant surgical method, disengages the periodontium before the removal of the tooth. The periodontium is maintained and its structure is maintained in relation to the interior wall of the socket. Unencapsulated nerve elements and free nerve endings are preserved along with this. Immediate implant placement, tried in the recent times provides a close fit status to the implant. Many of the experiments mentioned here were conducted on animal models like rats. However, these may open up new vistas of neural integration for the implants [33].

Conclusions

An edentulous person when he is undergoing complete or partial denture treatment finds it difficult to masticate in the initial phases. After a few months, the same individual masticates with ease, using the same dentures. This happens because of neuroplasticity which is the ability of the brain to change its structure and function. By neuroplasticity, brain develops new networks and neural structures and functions get modified. When new experiences are given, new connections and new neurons are developed. If certain functions are not in use, neural networks get pruned. New skills are learned because of neuroplasticity. In advancing age also neuroplasticity remains functional. Dental professionals who thought that they cannot learn the implant treatment methods, have avoided acquiring the skills. Now the scene has changed dramatically. The number of dental implantologists presently available are many and this has made the treatment popular and accessible to the common man. This scenario can be attributed to neuroplasticity. Dentists should not stop reading professional journals and text books and keep neuroplasticity active. Knowledge and skill levels can be kept current by engaging in physical and intellectual activities. Recovery from brain injuries is possible because of neuroplasticity. A right-handed person loses the right hand in an accident. By practice, the person can write well with the left hand and that is due to the effect of neuroplasticity.

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Figure credits

Figure 1. https://www.amazon.in/Principles-Psychology-1-2-William-James/dp/1543183182

Figure 2. https://www.worthpoint.com/worthopedia/conditioned-reflexes-neuron-1720532993

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