OPEN ACCESS

Review Article

Journal of Dental Science, Oral and Maxillofacial Research

Harnessing neuroplasticity in oral and maxillofacial medicine – a systematized review

Dr Sindhu Poovannan

Oral Medicine and Radiology, The Tamil Nadu Dr. M.G.R. Medical University, India

Correspondence: Dr Sindhu Poovannan, Senior Lecturer, Oral Medicine and Radiology, Tagore Dental College and Hospital, The Tamil Nadu Dr. M.G.R. Medical University, Rathinamangalam, Chennai, India, Tel: 7200058920, Email drsindhumds@gmail.com

Received: June 23, 2023 | **Published:** October 27, 2023

Abstract

Plasticity refers to the ability to adapt. In general, all organisms exhibit phenotypic plasticity. This nature of organisms plays a vital role in ecological balance and evolution.Plasticity occurs at the micro-environment as well. Neurons in brain exhibit plasticity which is referred to asneuroplasticity. Studies reveal that exercise and goal-based repetitive training have improved neuroplasticity. The attempt to restore lost function due to injury has been observed in brain through equipotentiality and vicariation. Enhancing neuroplasticity in geriatric patients with neuromuscular disorder requires an inter-professional team. Restoring oral health and function along with inter-professional therapy and follow-up would definitely make a good improvement in their overall quality of life.Foundational research has paved way for future studies on harnessing neuroplasticity in oral and maxillofacial medicine.

Keywords: neuroplasticity, neuromuscular disorders, Parkinson's disease, oral rehabilitation, oral and maxillofacial medicine

Introduction

Plasticity refers to the state of being plastic, i.e., the ability to mould or adapt. In general, all organisms exhibit phenotypic plasticity. It means that an individual set of genotype can manifest through different phenotypes when subjected to different environment. This nature of organisms plays a vital role in ecological balance and evolution.[1]

Plasticity in the macro-environment

Organisms are constantly evolving on earth. Phenotypic plasticity has contributed to this evolution at a major level. Phenotype is the physical manifestation of an organism which is dictated by its genotype or genes. This phenomenon can be understood from plants. Photosynthesis in plants require carbon dioxide, water and sunlight. A plant when grown in carbon dioxide rich atmosphere exhibits lower stomata density, whereas the same genotype plant when grown in an atmosphere with low carbon dioxide exhibits higher stomata density to accomplish the same level of photosynthesis.[1,2]

Another interesting phenomenon seen in turtles and certain reptiles is temperature dependent sex determination. The temperature at which the turtle eggs are incubated determines the turtle's gender.[2] Further all species exhibit "life long plasticity". This is the ability of an organism to adapt based on its external environment throughout its lifespan. Fur thickness change in mammals, feather moulting in birds, learning and training in humans are all features of life long plasticity. The exhibit of plasticity could be morphological, physiological and behavioural.[1,3]

Neuroplasticity - plasticity in the micro-environment

Plasticity occurs at the micro-environment as well. Neurons in brain exhibit plasticity and this phenomenon is referred to as 'neuroplasticity / neural plasticity / brain plasticity. William James in 1890 was the first person to use the term plasticity in relation to the nervous system. Later, Jerzy Konorski in 1948 coined the term neural plasticity and Donald Hebb in 1949 popularized the concept.[3]

Neuroplasticity could be best definedas "the ability of the nervous system to change its activity in response to intrinsic or extrinsic stimuli by reorganizing its structure, functions, or connections." Upon closely observing the neurons, it has been found that they can alter their synaptic connections and perform functional reorganization either after an injury or based on the requirement. Fetal neurons in particular, exhibit this quality exponentially.[4,5]

Brain studies have revealed another fascinating phenomenon. When one brain hemisphere undergoes functional loss due to injury, the other half of the brain attempts to take over the lost function. This quality is referred to as equipotentiality. Another way of brain repair attempt is by assigning functions to other regions of brain that was originally not meant for that function. This is known as vicariation. Clinically, patients who have suffered cerebrovascular accident (stroke) and traumatic brain injury have exhibited such repair attempts and this is possible only due to neural plasticity.[4,6]

However, neuroplasticity is not known to be always beneficial. There are studies that mention the neutral and maladaptive type of neuroplasticity. Neutral meaning no changes achieved and maladaptive refers to pathological / negative consequences. One example of maladaptive plasticity is 'phantom limb pain', the pain perceived by an individual in an amputated limb. Such patients have been treated with 'mirror therapy', an attempt to rewire the brain in relation to the functional limb.[7]

Having understood neural plasticity, the next step would be to utilize it in medicine. Several studies have been performed to identify methods to harness neuroplasticity in favour of health.

Citation: Citation: Poovannan S. Harnessing neuroplasticity in oral and maxillofacial medicine – a systematized review. *J Dent Maxillofacial Res.* (2023);6(3): 81‒83. DOI: 10.30881/jdsomr.00069

Enhancing neuroplasticity through exercise

Research has revealed that exercise improves brain plasticity. One obvious reason would be that exercise enhances cellular level blood circulation, oxygen supply and metabolism. Apart from this, 'repetitive goal-based exercises' improves neuroplasticity with beneficial effects. Studies have also proved neuroprotective and neurorestorative effects of exercise leading to improved automaticity and motor functions. This is achieved throughpreservation of Dopaminergic neurons (DA), increase in neurotropic factors like brain-derived neurotrophic factor (BDNF) or glial-derived neurotrophic factor (GDNF), enhancing vesicular release of dopamine and increasing synaptic occupancy.[4,8]

When a synapse is being subjected to a particular stimulus repeatedly, the neuronal connection strengthens. One such example would be constraint induced movement therapy (CIMT). Here a hemiplegic patient would be constrained on the functional limbs and encouraged to perform tasks repetitively using the affected side limbs. This therapy has proven to be beneficial in stroke patients.[7,9]

Neuromuscular disorders in oral medicine

In oral and maxillofacial medicine, patients with neuromuscular disorders present with oral and dental complaints. The oral manifestation could be due to their neuromuscular condition or any other dental disease. Neuromuscular disorders are conditions that exhibit muscle impairment associated with a nerve pathology. Cerebrovascular accidents (CVA)/stroke, Parkinson's disease, Huntington's disease, myasthenia gravis patients are frequently encountered by oral and maxillofacial physicians especially in the geriatric population.[10]

Motor and sensory deficits, expression-less mask like face, xerostomia due to anti-cholinergic medications, dysphagia, dysarthria, dyskinesia, gait imbalance are certain signs that could be anticipated from patients of neuromuscular disorders. All these indicate poor motor skills that lead to poor oral hygiene and edentulism. Patients with neuromuscular disorders could experience significant weight loss owing to this factor. Ironically, muscle wasting or dyskinesia experienced by these patients demand a higher calorie intake.[4] The ultimate goal is to restore and maintain their oral health and function in order to improve the systemic health.

Patients with neuromuscular disorders like Parkinsonism may require oral rehabilitation. Several case reports indicate oral rehabilitation in Parkinson's patients with removable dentures. Besides intense patient care and attention during the dental appointment, follow-up of such patients is very vital for good prognosis.[7,8]

Harnessing neuroplasticity

Some of the difficulties the patient would face are denture insertion and removal, denture hygiene, speech practice along with denture, mastication, swallowing and denture retention. This is where neuroplasticity could be clinically harnessed in oral and maxillofacial medicine. Repetitive goal-based training could be directed towards digital dexterity; eye and limb coordination; lip, tongue and masticatory muscle coordination for denture retention and mastication; speech training; denture insertion and removal; oral and denture hygiene practice and centric relation at maximal intercuspal position practice.[3,11]

Neuroplasticity in Parkinson's disease has been studied extensively in animal mice model. MPTP (1-methyl-4-phenyl-1,2,3,6-tetrahydropyridine) induced Parkinson's lesion in substantia nigra of mice brain have been researched using sequential functional MRI (fMRI). The study findings concluded that exercise have significantly improved neuroplasticity in affected brain regions.

The major goals would be to achieve goal-based motor skill training; instruction and feedback (reinforcement); encouragement to perform beyond self-perceived capability and improve cognition with practice and learning.[4,12]

Concluding remarks

Neuromodulation in ageing patients with systemic illness is relatively slower compared to a healthy young adult. Hence, enhancing neuroplasticity in geriatric patients with neuromuscular disorder is a challenging yet possible task that requires an inter-professional team. Oral and maxillofacial physician, neurophysician, psychotherapist, speech therapist, nutritionist and physiotherapist would make a complete therapy team for such patients. Educating the care-taker also plays a crucial role. Restoring oral health and function along with inter-professional therapy and follow-up would definitely make a good improvement in their overall quality of life. Foundational research has paved way for future studies on harnessing neuroplasticity in oral and maxillofacial medicine.

Acknowledgments

None.

Conflicts of Interest

None.

References

1. Fusco G, Minelli A. Phenotypic plasticity in development and evolution: facts and concepts. *Philos Trans R Soc B*. 2010;365(1540):547–556.
2. Charnov EL, Bull J. When is sex environmentally determined? *Nature*. 1977;266(5605):828–830.
3. Puderbaugh M, Emmady PD. Neuroplasticity. 2023.
4. Petzinger GM, Fisher BE, McEwen S, Beeler JA, Walsh JP, et al. Exercise-enhanced neuroplasticity targeting motor and cognitive circuitry in Parkinson's disease. *Lancet Neurol*. 2013;12(7):716–726.
5. Redgrave P, Rodriguez M, Smith Y, et al. Goal-directed and habitual control in the basal ganglia: implications for Parkinson's disease. *Nat Rev Neurosci*. 2010;11(11):760–772.
6. Fisher BE, Wu AD, Salem GJ, et al. The effect of exercise training in improving motor performance and corticomotor excitability in people with early Parkinson's disease. *Arch Phys Med Rehabil*. 2008;89(7):1221–1229.
7. Al-Omari FA, Al Moaleem MM, Al-Qahtani SS, et al. Oral rehabilitation of Parkinson's disease patient: a review and case report. *Case Rep Dent*. 2014;2014:432475.
8. Haralur Satheesh. Clinical Strategies for Complete Denture Rehabilitation in a Patient with Parkinson Disease and Reduced Neuromuscular Control. *Case Rep Dent*. 2015:352878.
9. Herman T, Giladi N, Gruendlinger L, et al. Six weeks of intensive treadmill training improves gait and quality of life in patients with Parkinson's disease: a pilot study. *Arch Phys Med Rehabil*. 2007;88(9):1154–1158.
10. A Khator, M Motwani. Neuromuscular disorders affecting the Oral and Maxillofacial region and their Dental management. *International Journal of Dentistry Research.* 2019;4(1):13–19.

Citation: Poovannan S. Harnessing neuroplasticity in oral and maxillofacial medicine – a systematized review. *J Dent Maxillofacial Res.* (2023);6(3): 81–83. DOI: 10.30881/jdsomr.00069

11. Allen NE, Canning CG, Sherrington C, et al. The effects of an exercise program on fall risk factors in people with Parkinson's disease: a randomized controlled trial. *Mov Disord*. 2010;25(9):1217–1225.
12. Cameron IG, Watanabe M, Pari G, et al. Executive impairment in Parkinson's disease: response automaticity and task switching. *Neuropsychologia*. 2010;48(7):1948–1957.

Citation: Poovannan S. Harnessing neuroplasticity in oral and maxillofacial medicine – a systematized review. *J Dent Maxillofacial Res*. (2023);6(3): 81–83. DOI: 10.30881/jdsomr.00069