Enhancement of Nerve Regeneration by Therapeutic Laser

Therapeutic laser shows promise as an accelerator of healing and neural regeneration in the central nervous system.

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Injuries to the nervous system affect over 90,000 people every year.[1] Spinal cord injuries alone account for over 10,000 annually.[2] Damage to the lower spinal column can result in paraplegia or quadriplegia.[3] Nerves can be damaged either through disease or trauma. Trauma to the nerves can occur as a consequence of motor vehicle accidents, severe falls, lacerations, and typing. Traumatic injury, such as falls and motor vehicle accidents can lead to the severing of nerves. Several diseases can damage nerves. They include multiple sclerosis, diabetes, spina bifida, and polio.

In this article we will discuss some of the basic concepts relating to nerve regeneration and its response to therapeutic laser. Several research studies will be cited.

Nerve Injury

Peripheral nerve injury immediately elicits the migration of Schwann cells, phagocytic cells, and macrophages to the damaged tissue site in order to clear away tissue debris.

Initially after injury, there is swelling of the proximal end of the nerve and is subsequently accompanied by retrograde degeneration. Once the debris has been cleared, axonal sprouting begins to occur.

Regeneration, however, is limited to the central nerve system and not the peripheral nerve system. The glial cells and extracellular environment exert an inhibitory influence on the regeneration process. Central nerve system lesions have been shown to re-grow in acceptable environments. Therefore, the primary issue nerve regeneration in the central nerve system is crossing or eliminating the inhibitory lesion site.[1]

Beirowski et al[4] describe the degeneration following nerve injury as follows (in reference to Figure 1A-H):

"After a latency period Wallerian degeneration following cut and crush injury starts abruptly in single axons and involves total fragmentation of axons within a few hours. A-D: Conventional fluorescence micrographs of a ~2.5 cm long peripheral nerve stump (sciatic-tibial nerve segment) wholemount preparation at the proximal (A) and distal site (B) 37 h after cut injury with few individual fluorescent axons broken into fragments. A small number of axons fragmented at the proximal (C) and distal site (D) of a peripheral nerve stump wholemount preparation could also be detected 40 h following crush injury.

"E-H: Conventional fluorescence micrographs of a ~2.5 cm long peripheral nerve stump (sciatic-tibial nerve segment) whole mount preparation at the proximal (E) and distal site (F) 42 h after cut injury with most YFP labelled axons fragmented. A similar picture with a majority of axons degenerated is evident at the proximal (G) and distal end (H) of a peripheral nerve stump whole mount preparation 44 h after crush injury. YFP fluorescence has been pseudo-coloured green with the applied imaging software (MetaVue, Universal Imaging Corp)."[4]

Study Synopses

van Breugel observed that HeNe laser irradiation stimulated proliferation of Schwann cells in rats. Schwann cell proliferation is an essential part of Wallerian degeneration after nerve damage and thus a prerequisite for regeneration (see Figure 1).[5]

Rochkind et al observed accelerated fiber spouting and neuronal cell migration from aggregates in embryonic rat cultures embedded in hyaluronic acid/laminin gel after infrared laser irradiation with a GaAlAs 780nm laser.[6]

Rockhind, in another double-blind placebo controlled pilot study, showed

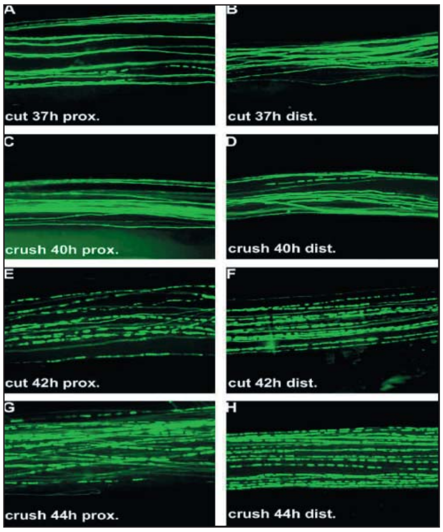

FIGURE 1A-H. *Wallerian degeneration in cut and crushed nerves.[3] Magnification100x* that the 780nm laser accelerates and enhances axonal growth and regeneration after injury or a reconstructive peripheral nerve procedure.[7]

In yet another study by Rockhind, it was found that at three months post sciatic nerve transection and removal in 20 rats, there was a positive somato-sensory evoked potential in 70% of the laser-irradiated rats as opposed to 30% of the non-irradiated rats. The laser-irradiated group had an increased number of total number of myelinated axons.[8]

Mohammed et al studied the effects of infrared laser on histopathological changes in rats that had surgical transection of their peroneal nerves. The laser irradiated group had a thicker diameter of the nerve fibers, more regular myelin layers, and clearer nodes of Ranvier.[9]

Bae et al studied the morphological changes that occurred in surgically crushed sciatic nerves in rats. The rats that received laser-irradiation underwent nerve conduction study and light and electron microscopy of the sciatic nerve. The numbers of myelenated axons decreased and degenerated axons increased compared to the control group. These parameters all recovered almost to the pre-trauma level in the laser-irradiated group.[10]

Shamir et al studied the therapeutic effect of low-powered laser on peripheral nerve regeneration after complete transection and direct anastomosis of the rat sciatic nerve. Positive somatosensory evoked responses were found in 69.2 percent of the irradiated rats as compared to 18.2 percent of the non-irradiated group. Immunohistochemical staining in the laser treated group showed an increase in the total number of axons compared to the non-irradiated group.[11]

Rochkind et al conducted a study on 31 rats in which spinal cord transection was performed between T7/T8. In vitro implants containing embryonal spinal cord neuronal cells were used in the transected area. The laser-irradiated group showed different degrees of active movements in one or both legs, axonal sprouting as soon as three days after surgery, and somatosensory evoked potentials.[12]

Erlicher et al has used 800nm infrared laser to guide the direction of nerve cell growth (growth cone) in vitro and in vivo.[13]

Shin et al observed that low-power laser irradiation increased neuronal regeneration by finding elevated immunoreactivities of growth-associated protein-43 (GAP-43), which is up-regulated during neuronal regeneration in the laser-irradiated rat group as compared to the control rat group. The irradiated rat group scored a higher sciatic functional index (FTI) score at 3-4 weeks than the non-irradiated group.[14]

Miloro et al investigated the nerve regeneration effect of therapeutic laser irradiation on surgically-created defects in the rabbit inferior alveolar nerve. Gross examination of the nerves showed intact neural bundles with various degrees of osseous remodeling. Light microscopic examination revealed organized regenerated neural tissue in both groups. Histomorphometric evaluation revealed increase axonal density in the laser-treated group as compared with the control group.[15]

> "Therapeutic laser always produces immediate local effects in the tissues that are irradiated... and should be considered in common post-traumatic conditions such as motor vehicle accidents, sports injuries, and work-related injuries."

Khullar et al conducted a double blind clinical study on 13 patients (eight in the laser group and seven in the control group) who had undergone saggital split ramus oseotomy resulting in either compression or traction of the inferior alveolar nerve and accompanying paresthesia. The laser-irradiated group experienced subjective improvement in both the lip and chin. No similar tendency was observed in the placebo group. The laser group exhibited a strong improvement in mechanoreceptor neurosensory deficit.[16]

Yamada has compared corticosteroids, laser therapy, and a combination of the two utilizing three groups of seven patients. The effect of the laser group was comparable to corticosteroids. The combined group had even better results.[17]

Brugnara treated two groups of patients with inferior alveolar and inferior nerve parasthesias with a GaAlAS infrared laser following surgical interventions. Positive results were observed in 72.7% of the patients treated within the first 15 days as opposed to 27.7% in the group treated 30–365 days after surgery.[18]

Paolini treated 40 patients with Bell's palsy. One group received only prednisone while the other group was treated with a GaAs laser at points along the nerve. The outcomes in the laser group was significantly better than in the pharmaceutical group.[19]

Muakami treated 52 people diagnosed with facial paralysis or Bell's palsy. Twenty-six were treated with stellate ganglion block, 11 received infrared laser and 15 received both laser and SGB. He observed that the laser treated group and the combined laser and SGB group showed similar recovery from paralysis.[20]

Rockhind et al evaluated functional improvement in 18 patients suffering from incomplete peripheral nerve or brachial plexus injuries. In this placebo controlled double-blind study, one group received laser therapy and the other received placebo for 21 days. There was significant improvement in the laser-treated group as compared to the placebo group at three and six month follow-up.[21]

Conclusion

We can see from the above studies that therapeutic laser shows promise as an accelerator of healing and in neural regeneration. We have seen in previous articles in this journal that therapeutic laser has been found to be of value in the treatment of a variety of neural-related conditions such as trigeminal neuralgia, neuropathy, low back pain with sciatica, and herpes zoster. Therapeutic laser always produces immediate local effects in the tissues that are irradiated as well as systemic effects. Together, these effects trigger the healing responses that are well documented with this modality and should be considered in common post-traumatic conditions such as motor vehicle accidents, sports injuries, and work related injuries. ■

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