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The optimization of peripheral nerve recovery using cortical reorganization techniques: A retrospective study of wrist level nerve repairs

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ABSTRACT

Study design: Retrospective case series.
Introduction: Outcomes following peripheral nerve repairs have not significantly improved over the past few decades. A new protocol using cortical reorganization techniques was developed with the goal of improving nerve recovery in the hand.
Purpose of the study: To determine if early sensory re-education using cortical reorganization techniques improved sensory outcomes in the hand after repair of wrist-level nerve injuries.
Methods: A retrospective study was completed of wrist-level peripheral nerve repairs in patients who underwent a sensory re-education protocol which included cutaneous anesthesia, tactile stimulation, and sensory and motor imagery. Data for static 2-point discrimination, Semmes Weinstein monofilament assessments and the shortened version of the Disabilities of the Arm, Shoulder and Hand (QuickDASH) scores were collected.
Results: At four months post-repair, three of seven of the median nerve lacerations had static 2-point discrimination of 7 mm or less in at least one digit. Using the Semmes Weinstein monofilaments, 9 of 11 nerve repairs felt the 4.31 filament (protective) or better by eleven months with five able to perceive the 2.83 filament (normal) in that time frame.
Conclusions: This limited retrospective study suggests that early sensory re-education using cortical reorganization techniques may improve sensory outcomes. A larger scale study is indicated to confirm our findings.
Level of evidence: IV

Introduction

Since sensory re-education was initially advocated by Wynn-Parry and Dellon in the 1970s and published in Dellon's book in 1981,[1] little has changed in the field of sensory re-education until the recent introduction of the concept of cortical reorganization.[2–5] Sensory re-education is the technique following nerve repairs to retrain the altered response from misdirected axons which occurs as nerves regenerate.[4] Treatment emphasis has been on touch localization and discrimination, and is traditionally not initiated until the patient perceives touch at four to six months following nerve repair.[1] A literature search provided 3 studies that addressed sensory re-education and outcomes following peripheral nerve repairs. The sensory re-education techniques used in all 3 studies were those discussed by Dellon. Two studies 1 by Mavrogenis and 1 by Imai used 2-point discrimination and 1 study by Imai used Semmes Weinstein monofilaments to report outcomes.[6–8] It is recognized that following a peripheral nerve injury, the sensory cortex changes quickly due to the lack of input from the damaged axon.[3,5] To minimize the effects of cortical silence and possible encroachment on the site by surrounding neurons, Lundborg and Rosen have proposed initiation of cortical re-organization techniques.[3,4] Changes in the cortex can be modified using techniques that substitute other senses for the lack of peripheral input from injured nerves. A glove with sensors to provide auditory feedback to substitute aural for tactile sensation indicated improved sensory recovery.[9] In the case report by Rosen, the patient's sensation was improved with the use of the sensor glove when compared to the level predicted by earlier studies using the outcome measure, the

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Model Instrument for Outcome After Nerve Repair.[9–11] The use of local cutaneous anesthesia to block adjacent innervated skin has been shown to minimize input to the brain from sensate areas.[5] The theory behind cutaneous anesthesia is that migration of neurons from adjacent "normal" cortical areas into the "silent area" will be slowed. An eutectic mixture of local anesthetic (EMLA) cream is applied to adjacent sensate skin to increase the "silent area" in the cortex. Three studies have shown improved tactile sensation following local cutaneous anesthesia in both normal individuals and following nerve repairs.[5,12–14] In a study involving 13 wrist-level peripheral nerve repairs that regained only protective sensation, patients were randomly assigned to either receive local cutaneous anesthesia or a placebo followed by sensory re-education. The distal sensation of the group receiving the cutaneous anesthesia significantly improved after 6 weeks with no significant change in the placebo group.[9]

The literature indicates sensory recovery following peripheral nerve repair in adults is less than satisfactory and the addition of cortical reorganization techniques in a sensory re-education program could improve sensory outcomes. The cortical reorganization program should also be initiated as soon as possible following nerve repair as the sensory cortex will change as soon as a nerve is injured. Our program incorporates early cutaneous anesthesia, tactile stimulation with a variety of textures, sensory imagery and motor imagery to improve sensory outcome following peripheral nerve repair.

Our facility uses the shortened version of the Disabilities of the Arm, Shoulder and Hand (QuickDASH) Outcome Measure to note an overall change in how the patient perceived his disability. The QuickDASH is a self-report questionnaire to measure physical function and symptoms in patients with musculoskeletal disorders of the upper extremity. It is considered valid, reliable and responsive.[15] A literature search found no studies specifically addressing any correlation between sensory recovery and QuickDASH scores.

The purpose then of this retrospective study was to determine whether a sensory re-education program that included early cortical reorganization techniques would improve sensory outcomes. A change in the static 2-point discrimination and Semmes Weinstein testing with the score in both tests moving toward the "normal" range was used to determine improved sensory outcome. The QuickDASH score was used to indicate patient's perceived impairment, a decrease in the score indicated decrease in symptoms and increased function.

Method

The hand therapy clinic consisted of 8 occupational therapists with 8–34 years of experience in hand therapy. To ensure there was consistency between therapists the standardized technique for sensory assessments was reviewed and all therapists were instructed in the cortical reorganization treatment protocol by the primary author (BW).

The cortical reorganization protocol for sensory re-education was initiated as soon as possible following any peripheral nerve repair, ideally within two weeks. The purpose of beginning the program early was to intervene in the cortical modifications that begin as soon as the damaged axons stop sending messages to the cortex. The program incorporated cutaneous anesthesia, tactile stimulation with a variety of textures, sensory imagery and motor imagery.

Patients were instructed in a home program and demonstrated understanding of the treatment program. The EMLA cream (prescription required), was applied proximal to the nerve injury over a 10 cm by 8 cm area of intact skin. For a wrist level injury the cream was applied proximal to the injury on the distal forearm. The EMLA cream was thickly applied and covered with plastic wrap for 1 hour to allow the lidocaine and prilocaine to inhibit local nerve conduction resulting in local anesthetic. The skin should be numb and may blanch initially followed by local redness. Once the area was numb, the denervated area was rubbed with materials of various textures: cotton balls, soft cloth, terry-cloth, hook and loop Velcro™ and sandpaper were used. It was important to *not* stimulate sensate areas or the area anesthetized with EMLA cream. The patient was to be fully engaged with the tactile stimulation: visually watching it, thinking about how the texture *should* feel and even listening to auditory input such as skin on sandpaper. This was to be completed twice a week for 1 month and then once a week for 4 months.

In addition to the use of the EMLA cream and tactile stimulation, the patient was to use the textures a minimum of 5 times a day for 5 min, again rubbing only the numb areas and concentrating on the imagery of the texture and the actual sound it made against the skin.

Patients also performed sensory and motor imagery often throughout the day. Patients were to imagine how things feel – the dog's fur or the peel of an orange. To facilitate motor imagery they were given a laminated wallet card with a list of 15 action verbs to read out loud throughout the day. As they read the verbs, they visualize themselves doing the activity. The words we chose were run, swing, jump, throw, hit, ride, pinch, swim, dance, climb, skip, tumble, catch, grab, and walk. There was no prescribed list of words. The words we selected were picked at random. If the patient preferred different words with specific meaning to them, that would have been acceptable. Patients were also instructed in mirror therapy to again provide substituted sensory input. This was initially done in the therapy clinic, and patients were encouraged to try to find a way to complete this activity 1–2 times a day at home. The impaired hand was behind a mirror and the unaffected hand was stimulated with textures or objects as patient looked at the image in the mirror, in effect, substituting the image for the impaired hand. Patients were to continue with the home exercise program until they perceived touch at which time the traditional sensory re-education was added to the home program.

Once the perception of touch returned, as evident by sensory assessment, the therapist instructed each patient in traditional sensory re-education techniques. These included static and moving touch localization, graded textures and object identification. The stimulation was presented with vision blocked, and the patient tried to identify the stimulation. Then the same stimulation was presented under direct vision as the patient concentrates on the sensation followed again with vision blocked. Patients were also instructed to put objects in their pocket and try to identify them. Patients were instructed to continue sensory re-education couple times a day until sensation was acceptable to them. The sensory re-education program including both the initial cortical reorganization techniques and the second phase of traditional re-education techniques could be completed independently by the compliant patient as a home program with follow ups in revisits to therapy to monitor sensory return and to progress the program.

The cortical reorganization techniques were typically initiated within two weeks of surgery. Visit frequency is determined by concomitant injuries and the patient's ability to follow through with home program. Typically patients were seen 2 times a week for 2 weeks followed by 1 time a week for a month then 1 to 2 times a month. Sensation assessed at 1, 3 and 6 months after nerve repair. Static and moving 2-point discrimination and Semmes Weinstein monofilament sensory assessments were conducted as described by Bell.[16] Static and moving 2-point