The influence of the CMMS technique on Motor Cortex Re-Patterning by Robyn Midgley

Background to Motor Cortex Re-Patterning (MCRP)

Clinical application of the Casting Motion to Mobilise Stiffness (CMMS) technique is an exciting development in the management of the stiff hand because of the role that therapists have in influencing the brains circuitry through neuroplasticity. Neuroplasticity describes a very simple process – the process of the brain wiring and re-wiring itself. The message is clear – neurons that fire together, wire together and has been defined as Hebb's Law (1)

The outstanding process of neural wiring is in full momentum throughout all stages of the developing embryo. Once we leave the womb, a whole new set of dynamics begins. The shaping and wiring of the brain becomes influenced by the environment. Not only are the synapses being created, but they are being pruned away as well. Which synapses remain and which are pruned depends entirely on whether the circuits carry any traffic. It is survival of the busiest connections that are used which become stronger, and those that are not are pruned away (1)

In the book The Developing Mind, Daniel Siegel writes about how our environment provides us with not just our experiences, but effectively wires the brain as we process this information. This inner tapestry of neurons firing and synapses connecting, forming into circuits, is being orchestrated by the signals the brain receives from our experiences. Each new experience is being assimilated and incorporated into the system (2).

The cerebral cortex is a dynamic structure in which the central core systems guide the selection of subcortical inputs, subcortical outputs, and intrinsic cortical connections based on events that are of behavioural relevance (3).

When a hand injury occurs, the primary motor cortex (M1) is vulnerable to the pathological or traumatic changes in relation to everyday experience (4). This is because the M1 contains a coarsely organized map of motor movement representations with movements driven through the neurons in the base of the spinal cord represented most medially, and facial muscle movements represented most laterally (3).

An orthopaedic disorder that reduces a patients motoric repertoire in the absence of any neurological impairments is sufficient to induce neuro-functional changes in the cortical representation of hand movements (5). Without attention, plasticity is severely limited. A reduction in plasticity will occur in the cortical area representing the skin surface engaged with a task. Conversely, heavily practiced behaviour causes cortical plasticity.

Practiced movements result in enhanced representations in the primary motor cortex. Multiple joint movements can be represented together in the M1 with greater than normal frequency.

Plastic changes occur in the contralateral and ipsilateral side of the brain because of transcollossal connections between the areas (6). These transcollossal connections are extremely relevant as it has been proposed that balanced interhemispheric interactions within the sensorimotor networks are required for the generation of proper unilateral voluntary movements (7-9) and interhemispheric balance can influence functional recovery.

The hand is the most commonly injured part of the body. Motor movements are impoverished in patients with long term joint stiffness as a result of reduction in plasticity. As the brain re-organizes itself to compensate for function that has been compromised or lost, neuroplasticity potential is driven by changes in behavioural, sensory and cognitive experiences.
For example, reliance on the less affected limb after a hand injury will be associated with major restructuring and neuronal growth in the unaffected contra-lateral hemisphere. This reliance may also limit the propensity of individuals to engage in behaviours that improve function of the injured hand (10).

Failing to engage the brain due to lack of use may lead to further degradation of function. These concepts of 'use it or lose it' and 'use it to improve it' are well known in neuroscience plasticity literature (10) and must be applied to the treatment of the stiff hand.

How does CMMS influence MCRP?

The stiff hand is essentially "immobilized" by edema and tissue adherence and is therefore used less and/or with a maladapted movement pattern for daily activities. As this is occurring, the motor and sensory cortical representation of normal, synergistic motion is diminishing and being replaced by a maladaptive patterning instead. When abnormal patterns of movement are repeated over time, they give way to changes in the motor cortex (11)
Human and animal studies have consistently demonstrated decreased cortical activity with lack of use (3, 10-12). These changes in brain patterning happen rapidly. For example, as little as 12 hours of arm immobilization begins to degrade one's motoric performance (13).

As stiffness persists, these neural circuits are reinforced and are more challenging to alter. Alternatively, it has been proven that repeated, challenging movements can enhance neural networks and expand the motor cortex (14).

This was demonstrated in Braille readers whose first dorsal interossei muscle of their dominant hand revealed a greater cortical representation than in the non-dominant hand or that of non-Braille readers (13).

As the treatment of joint stiffness is both a complex mechanical and cerebral challenge, the Casting Motion to Mobilise Stiffness technique (CMMS), lends itself to influence motor cortex re-patterning by addressing the problems of edema, fibrosis, extensive tissue adherence and multiple joint stiffness simultaneously.

At a mechanical level, this occurs through the facilitation of joint motion in both directions, through active lymphatic pumping to control edema and through the circumferential pressure from the cast which pseudo massages the tissues during active digital motion.

At a cerebral level, the principles of motor learning are applied as the patient focuses their attention on moving the joints repeatedly and cyclically in the desired pattern of motion within the cast to reinforce a normal pattern of motion. Furthermore, the technique harnesses the benefits of proprioceptive input during mobilization as the sensory feedback encourages corticospinal excitability.

Proprioception is the sensory feedback mechanism for motor control. A large body of evidence supports this assumption; even if tactile and proprioceptive inputs project to the primary somatosensory cortex.

Physiological studies have demonstrated that proprioceptive feedback, together with tactile feedback, is largely stronger than tactile alone in activating or modulating M1 excitability (15-17). The CMMS technique provides both proprioceptive and tactile feedback, which enhances sensorimotor organization of the M1. One may enhance M1 excitability further by providing additional ad hoc muscle proprioceptive vibration to induce specific proprioceptive patterns to muscle groups. The vibration will exert an influence on the M1 neurons (18-20).

Why is CMMS the preferred treatment of choice in the stiff hand?

As research continues to evolve and guide practice, the lines between "biomechanical" and "motor learning" models begin to blur, as concepts from each intermingle. This is true in case of the stiff hand. A "therapeutic activity" may be simultaneously encouraging active tendon gliding, providing proprioceptive input and engaging the motor networks of bilateral cerebral hemispheres. The therapist will reinforce "normal" movement patterns, and therefore "normal" cortical representation, through available therapeutic techniques. At times, the most effective and efficient way to do this is simply by providing a verbal or visual cue. At other times, cues and/or traditional mobilization techniques are frustratingly unsuccessful.

Although cortical representation changes rapidly based on use, for re-patterning to become an ingrained, automatic, dominant motion, the motion must be repeated for long periods during the day and over many days and weeks (21-25) Re-patterning is enhanced by conscious, close attention to the desired motion (26), while unattended repetitive motion and passive motion result in little or no significant plasticity changes in the cortex (27, 28).

This helps explain why in practice, increased range of motion (ROM) is achieved with passive stretch but not carried over to the next session. A patient may be able to achieve wrist tenodesis when focusing their attention during rote exercise, but when their attention is divided in a relatively more complex task requiring grasp, the wrist falls back into flexion. Without external support of the wrist, this patient is constantly reinforcing a maladaptive grasp pattern during their daily activities outside of the clinic. From a neurological and therapeutic perspective, the patient requires more repetition to reinforce a normal grasp pattern.

The extensive research that has been done in motor recovery post-stroke has demonstrated that task-specific training is known to be a component of rehabilitation (13, 29). Additionally, activities that are ADL-directed and occupation-based, have been shown to be more beneficial than standard or rote exercises (30, 31).

It is up to the therapist to select a technique that is of most benefit, provides high levels of dosage and stress with ease of application. The exact parameters of dosage in terms of intensity, duration, and frequency of stress is still unknown. We need to rely on our observations of a positive influence of the dosage on healing tissue and the absence of a renewed inflammatory response. Skilled therapists blend programs to achieve favorable results.

Unlike more traditional treatment methods, the CMMS technique simultaneously mobilizes stiff joints, reduces edema, and generates a new pattern of motion to revive the cortical representation of normal motion. Traditional manual mobilization techniques and mobilization orthoses are less effective in the chronically stiff hand than in the newly stiff hand, because these techniques are intermittent and address only one problem at a time. The CMMS technique contradicts traditional treatment theory in several ways. First and most dramatically, active motion regains both active and passive joint motion. No passive motion, modality, or manual treatment is applied. Because the cast immobilizes proximal joints and allows only the stiff joints to move in the range and direction needed, motion is isolated and part of the hand is immobilized. Typically, therapists believe that immobilization of any joint is to be avoided and motion in all directions should be gained concurrently.

CMMS focuses on gaining the motion that is needed most, which may temporarily cause loss of motion in the other direction or loss of motion in the immobilized joints. This approach also contradicts the common assumption that one should never allow gains in one direction of motion at the expense of the other direction.
In the chronically stiff hand, the balance of motion is overwhelmingly in favor of the stiff pattern. The constrained motion within the cast allows the opposite pattern of motion to become dominant, while simultaneously mobilizing adherent tissues and evacuating the stagnant edema. Re-education of a more normal pattern of motion is facilitated by the restraints imposed by the cast and, when the patient is weaned from it, the motions temporarily lost while in the cast return (unless there is some specific anatomic injury preventing such return). In cases of altered anatomy following injury the therapist must be convinced that the reconstructed anatomy has the potential to return to the balanced motion before applying the CMMS technique. The same concern is not applicable to stiffness of uninjured joints resulting from immobilization.

CMMS can successfully mobilize severe stiffness that is unresponsive to traditional treatment (32). Because the patient is mobilizing only with active motion, treatment is not painful. Therapy sessions consist of re-evaluation, cast changes, and home instructions, creating a cost-effective treatment approach that is not overwhelming for neither the therapist nor the patient. As functional motion is regained, a very slow weaning from the cast wear is begun and the functional use of the hand continues the progression of mobilization.

Conclusion:

The CMMS technique is the preferred treatment method of choice for the stiff hand as it addresses the multitude of complex cognitive and mechanical interrelated problems simultaneously. Furthermore, it provides the perfect environment for the hand to heal within whilst receiving stimuli to enhance neural pathways to increase plasticity.

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