Journal of Hand Therapy 29 (2016) 323–333

Contents lists available at ScienceDirect

Journal of Hand Therapy

journal homepage: www.jhandtherapy.org

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Scientific/Clinical Article

Case Report: The casting motion to mobilize stiffness technique for rehabilitation after a crush and degloving injury of the hand

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ARTICLE INFO

Article history:
Received 4 August 2015
Received in revised form
4 March 2016
Accepted 25 March 2016

Keywords:
Degloving injury
Joint stiffness
Rehabilitation
CMMS technique

ABSTRACT

Study Design: Case report.
Introduction: This case report describes the use of the casting motion to mobilize stiffness (CMMS) technique in the management of a crush and degloving injury of the hand. The patient was unable to attend multiple hand therapy sessions due to geographic constraints. The CMMS technique involved the application of a nonremovable plaster of paris cast that selectively immobilizes proximal joints in an ideal position while constraining distal joints to direct desired motion over a long period. This uses active motion only. Traditional hand therapy techniques or modalities are not used. This treatment approach was beneficial to the patient as a minimum of 2 appointments per month were needed to regain functional hand use.
Purpose of the Study: To document the use of the CMMS technique as an effective treatment approach in the management of a crush and degloving injury of the hand.
Methods: The CMMS technique was applied to the patient's left (nondominant) hand 8 weeks after injury. The technique's aim was to improve the 30° flexion deformity of the left wrist and flexion contractures of the index, middle, and ring fingers with a total active motion of 0°. Orthotic devices and traditional therapy were applied once joint stiffness was resolved, and a normal pattern of motion was reinstated.
Results: At 6 months, substantial improvement was noted in wrist as well as metacarpophalangeal and interphalangeal joints. Total active motion exceeded 170° in all fingers excellent functional outcome resulted as measured with the upper limb functional index short form-10. The upper limb functional index increased from 0% to 55% of preinjury status (or capacity) over the 18 months of therapy.
Discussion: Brief immobilization through casting causes certain functional losses, but these are temporary and reversible.
Conclusion: Finger stiffness, edema, and tissue fibrosis were successfully managed with the CMMS technique without the need for attendance at multiple hand therapy sessions.
Level of evidence: Level V.

Introduction

Soft tissue injuries of the hand are frequently encountered in hand therapy clinical practice. Among these, degloving injuries are one of the most dramatic and can result in a number of complications including finger stiffness and potentially severe tissue adherence and fibrosis. Degloving injuries occur when skin and subcutaneous tissue are avulsed from underlying structures.[1] Bleeding from these injuries can be significant, and surgeons must act timeously to decontaminate the wound and restore vascular supply to tissues.[2,3] The presence of multiple fractures from a crush injury, poor vascularity of the remnant tissues, and exposure of the delicate structures in the hand may further complicate the surgical and therapeutic management.[1] As noted by Krishnamoorthy and Karthikeyan,[1] "… in no other hand injury is the role of hand therapy more important."

From a hand therapy perspective, traditional management of soft tissue conditions includes active and passive mobilization exercises, the application of intermittent force through the use of dynamic orthoses, and scar tissue management through the use of massage, vibration, and other techniques.[4-8] However, there is a paucity in the literature on what determines best practice for therapeutic management of degloving soft tissue injuries.[3] Each case has unique challenges and complications that require intensive rehabilitation and therapeutic skill to minimize debilitating

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http://dx.doi.org/10.1016/j.jht.2016.03.013

functional loss. Complications such as excessive inflammation, infection, pain, hematoma, delayed wound healing, complex regional pain syndrome, development of proximal interphalangeal joint (PIPJ) and distal interphalangeal joint (DIPJ) contractures, and scar contracture could occur and may all contribute to digital stiffness leading to poor functional outcomes.

Overly aggressive therapeutic regimens employed by therapists may contribute to poorer immediate results as mechanical stress can increase soft tissue flare-up and damage an already compromised lymphatic system the consequences can include persistent edema, increased fibrosis, and low-grade chronic inflammation.[9] These complications ultimately result in joint tightness, which prevents normal synergistic motion that can deprive the sensory motor cortex of joint motion feedback. Over time, repatterning of the sensory motor cortex occurs, and the development of a new abnormal pattern of motion is established. These complications are interdependent and need to be managed simultaneously to restore functional hand use.[9]

It is recognized that appropriate stress application to injured soft tissues can effect permanent change in the periarticular structures and surrounding musculature, thereby improving joint stiffness and function.[10] Optimal plastic deformation occurs through the application of low-load prolonged stress over prolonged periods. The specially designed casting motion to mobilize stiffness (CMMS) technique is one way the desired stress can be applied, and normal motion patterns regained.

The CMMS technique, developed by Colditz[11] over a number of years, was first published in 2002. It involves the use of a comfortable nonremovable plaster of paris (POP) cast that selectively immobilizes proximal joints in an ideal position while constraining distal joints so they move in a desired direction and range over longer periods. The technique contradicts traditional treatment methods as no passive motion, modality, or manual treatment is applied. Temporary loss of motion in the constrained joints occurs, whereas gains are made in the unconstrained joints. The constrained motion into either the desired intrinsic minus or the intrinsic plus position within the cast, depending on which movement pattern previously dominated digital flexion, facilitates the development of a new movement pattern and motor cortex repatterning, while simultaneously mobilizing adherent tissue and reducing edema.[9]

The benefits of focusing on dynamic soft tissue remodeling, rather than applying force, are well recognised.[12] The CMMS advantage is that the cast prevents excessive mechanical stress to the affected tissue, yet also allows for appropriate prolonged stress. This accommodates the physiological limits of the operated tissue to be applied through active motion only. A reduction in collagen cross-linking is consequently facilitated, which enables an elastic tissue response. Edema and fibrosis are reduced through a combination of tissue compression by the hardened static cast and skin motion created by digital flexion, which provides concurrent physical stimulation of superficial lymphatics. Scar healing results from prolonged low-load positive force that facilitates tissue elongation and influences scar remodeling.[13] Furthermore, scar healing is advanced through cast pressure and warmth, which reduces scar adherence.[9]

The unique properties of POP enable intimate material conformation with the scar tissue. This reduces both the possibility of developing pressure areas and the cast to skin sheer force.[11] Prolonged cast positioning results in permanent tissue length changes due to collagen fiber realignment. This is unlike the temporary elastic tissue response that occurs with removable orthoses. In addition, motor cortex repatterning occurs in a consistent and effective manner. Multiple treatment sessions are consequently unnecessary as traditional therapeutic techniques are not applied and patients' mobilize their joints actively within the cast until joint stiffness improves before scheduling a follow-up consultation.

After motion has been restored by a brief casting period, the intermittent use of orthoses and mobilization can maintain improvements in active range of motion (AROM). Without the initial casting step, the same mobility gains and permanent tissue changes may either not occur or take substantially longer to be achieved.

Purpose of the study

This case report aims to document the effective use of the CMMS technique in the management of a crush and degloving injury of the hand on a patient who was unable to attend multiple hand therapy sessions due to geographic isolation. The *International Classification of Diseases, Tenth Revision* injury codes include S61.8 (open wound of other parts of wrist and hand) and V38.09 (occupant of 3-wheeled motor vehicle injured in noncollision transport accident, driver, nontraffic accident, and during unspecified activity).

Methods

The patient and injury

The 44-year-old male patient was systemically and psychologically healthy with no known risk factors that influence circulation and healing. The patient worked as a self-employed electrician and is right-hand dominant. He sustained a traumatic injury of the left upper extremity when an off-road vehicle that he was driving overturned. He sustained a crush and partial degloving injury of the left hand where the skin of the palmar and dorsal aspect of the hand was avulsed. The left shoulder was dislocated. There were fractures to the base of metacarpals 2-4, the base of the proximal phalanx of the thumb, and ulnar styloid process. The dislocated shoulder was manually reduced in theater, and the metacarpal fractures were fixated with K-wires. The orthopedic surgeon debrided and expertly replaced the degloved tissue; however, postoperative venous congestion resulted in the loss of the tissue and skin (Fig. 1). The patient was then referred to a plastic and reconstructive surgeon who debrided the wound and performed a free tissue transfer using an anterolateral thigh (ALT) flap to cover the defect (Fig. 2). The free tissue transfer provided cover for the exposed tendons, soft tissue, and neuromuscular structures. An ALT flap permits more supple and pliable soft tissue cover when compared with skin grafts and facilitates the performance of secondary procedures such as tendon transfers and scar releases. A dermal substitute (Fig. 2) was used over the thumb where no vital structures were exposed. Dermal substitutes provide a framework for blood vessels and dermal skin cells to remodel damaged skin, thereby facilitating adequate donor site recovery.[14] A split skin graft was performed 21 days after the dermal substitute application (Fig. 2). The primary rehabilitation concerns were that the patient lived 2.5 hours' drive from the nearest hand therapy center and would be unable to attend weekly hand therapy. In addition, he would be unable to return to work as an electrician or assist his wife with family and home duties including care of their young child.

Clinical assessment

The patient was referred for hand therapy once discharged from hospital 8 weeks after the initial injury and received no hand therapy while hospitalized. He presented with a swollen hand with multiple joint stiffness, an insensate ALT flap, and altered sensation from nerve damage resulting in an 85% functional impairment of the left upper extremity—calculated from the Biometrics E-Link Upper Extremity Impairment Software (ICSW) using the American