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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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### 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.

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### 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.<sup>1</sup> Bleeding from these injuries can be significant, and surgeons must act timeously to decontaminate the wound and restore exposure of the delicate structures in the hand may further complicate the surgical and therapeutic management.<sup>1</sup> As

vascular supply to tissues.<sup>2,3</sup> The presence of multiple fractures from a crush injury, poor vascularity of the remnant tissues, and

noted by Krishnamoorthy and Karthikeyan,<sup>1</sup> "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

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massage, vibration, and other techniques.<sup>4-8</sup> However, there is a paucity in the literature on what determines best practice for therapeutic management of degloving soft tissue injuries.<sup>3</sup> Each case has unique challenges and complications that require intensive rehabilitation and therapeutic skill to

minimize debilitating 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.<sup>9</sup> 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.<sup>9</sup>

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.<sup>10</sup> 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<sup>11</sup> 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.<sup>9</sup>

The benefits of focusing on dynamic soft tissue remodeling, rather than applying force, are well recognised.<sup>12</sup> 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.<sup>13</sup> Furthermore, scar healing is advanced through cast pressure and warmth, which reduces scar adherence.<sup>9</sup>

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 shear force.<sup>11</sup> 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 3wheeled 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.<sup>14</sup> 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

Motor and sensory nerve function

A traction injury (axonotmesis) of the median and ulnar nerves was sustained at the wrist, affecting both motor and sensory nerve functions. Nerve conduction studies were not performed; therefore, SemmesWeinstein monofilament examination was used to assess sensory loss. Normal sensation threshold is 2.81. Testing of motor nerve function was constrained by the soft tissue injury and limitations; however, the motor status of each nerve is described.



Fig. 1. Venous congestion after degloving injury.

American Medical Association guides to the evaluation of permanent impairment (revised fourth and fifth editions).

Radial nerve. Normal sensation was present over the radial nerve dermatomes of the thumb, index, and middle fingers. Diminished light touch (3.22-3.61) was



ALT

DS

SSG

Fig. 2. Anterolateral thigh (ALT) flap, dermal substitute (DS), and split skin graft (SSG) surgical procedures.

Cosmesis

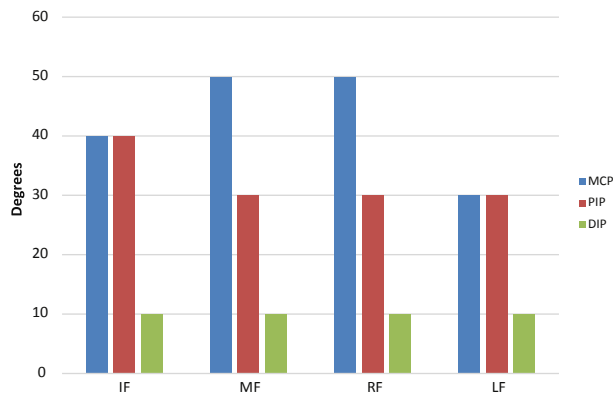
An ALT flap was present on the volar aspect of the forearm and hand. Trophic changes of the skin had occurred, and the scars were immature, red, flat, and immobile. The thumb split skin graft had healed adequately (Fig. 2).

Range of motion

AROM and passive ROM were assessed using standard goniometers. The patient presented initially with a 30 fixed flexion deformity of the left wrist and flexion contractures of the index, middle, ring, and little fingers (Fig. 3) with a total active motion (TAM) of 0 (Fig. 4). Passive ROM of the fingers was <10 due to the development of joint contractures from prolonged immobilization. The wrist could be passively extended from 30 to 20 flexion.

present on the dorsum of the fifth metacarpal. Absent sensation was present over the dorsum of the little finger. The motor status of the nerve was diminished innervation to the extensor pollicis longus, abductor pollicis brevis, and abductor pollicis longus muscles with grade 3 muscle strength in all 3 muscles.

Median nerve. Diminished light touch (3.22-3.61) was present in the index finger and radial aspect of the middle finger. Diminished protective sensation (3.84-4.31) was present in the thumb and ring fingers. Loss of protective sensation (4.56-6.65) was present in the volar aspect of the thumb over the thenar eminence. The motor status of the nerve was diminished innervation to the flexor pollicis brevis and abductor pollicis brevis muscles with a grade 3 muscle strength in each muscle.



interphalangeal; DIPFig. 3. Fingerfinger; LFflexion contractures. MCP% littledistal interphalangeal; IF% metacarpophalangeal; PIPindex finger; MF % middle% proximalfinger;

RF % ring % finger. %

Ulnar nerve. A low ulnar nerve injury had occurred with damage to the motor and sensory branches. Diminished protective sensation (3.84-4.31) was present in the little finger. There was no sensation over the expanse of the ALT flap. The motor status of the nerve was absent innervation to the palmar and dorsal interossei muscles, flexor digiti minimi, abductor digit minimi, and adductor pollicis with grade 0 muscle strength in all 3 muscles.

#### Pain

The 10-point verbal rating scale (VRS; 0 % no pain and 10 % extreme pain) was used to assess subjective pain intensity in the left hand. The VRS has been shown to correlate with the visual analog scale (VAS).<sup>15</sup> During weeks 1-8 postinjury, the patient described severe pain (VRS % 9 of 10) and was medicated accordingly. He described developing a high pain tolerance and accommodated to this pain. As hand therapy was initiated and his fingers mobilized, pain reduced and ranged from VRS % 0 (none) at rest to VRS % 4 with movement of the left forearm and hand throughout the application of the CMMS technique.

#### Functional ability

Upper limb function and impairment after an injury were assessed by using patient-reported outcome measures that assessed activity and participation to determine functional impairment of the upper limb.<sup>16</sup> The original upper limb functional

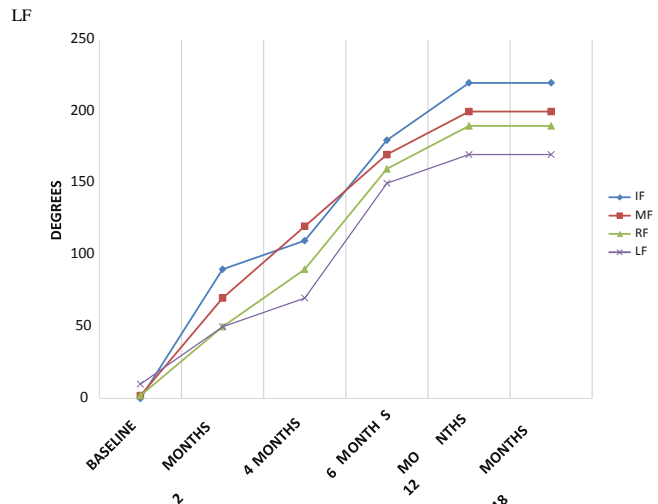


Fig. 4. Total active motion. IF % index finger; MF % middle finger; RF % ring finger; LF % little finger.

index (ULFI) was published in 2006 with a dichotomous response option<sup>16</sup> and later modified to a 3-point response that resolved clinimetric limitations surrounding psychometric properties and improved practicality.<sup>17</sup>

The 10-item short form of the ULFI, the ULFI-10, was developed after the ULFI-3-point response assessment to further enhance practical properties by reducing patient and therapist burden through ease of administration, scoring, and missing responses. The 3-point response option also reduced potential item redundancy.<sup>18</sup>

The ULFI-10 contains 10 items within 2 broad constructs, assessment of health-related quality of life, and upper extremity dysfunction, represented through a single summated score on a 0%100% scale. It has confirmed psychometric properties of a singlefactor structure, reliability, validity, and responsiveness.<sup>18</sup> The ULFI-10 raw scores range from 0 to 10 and are converted to a 0%100% scale, where the lowest score (0%) indicates total functional limitation and the highest score (100%) indicates maximum function or preinjury status. This reflects the individual's overall capacity and status as measure of ability rather than disability. An optional 5-item patient-specific index (PSI) section is present to interpret qualitative information, and a further 10-point numerical rating scale of global function (NRS-GF) concurrently assesses overall status. Both these scales are also scored as status or ability scale with the maximum being the preinjury or normal level.

#### Work performance

The patient is an electrician and owns a large company. His roles include administrative work, traveling, as well as manual and supervisory duties. Administrative tasks comprise 50% of his work duties and could be performed with 1 hand but took longer to complete. Manual tasks comprise 10% of his work duties and demanded a high degree of fine co-ordinated movement and dexterity of the fingers of the left hand. An assistant was needed for intricate work that involved fine coordinated movements such as wiring of distribution boards and control panels. The patient spent 20% of his time traveling/driving and was able to drive independently.

#### Hand therapy treatment plan

##### Treatment approach

Significant trauma to the soft tissue, muscles, bone, nerves, and vasculature of the hand resulted in the need for 8 weeks of immobilization to allow for postoperative healing to occur. During this prolonged immobilization, chronic edema and fibrosis with extensive tissue adherence developed with resultant multiple fixed flexion deformities of the wrist and digits with a TAM of 0 (Fig. 4). Prolonged immobilization and diminished

protective sensation in the median and ulnar dermatomes contributed to the development of sensory motor cortex deprivation as movement and functional use was not possible. The patient was at risk of developing an abnormal pattern of motion once he began to move because as movement in the stiff joints was regained, the patient would most likely exhibit movement in a dysfunctional pattern.

The geographic isolation required a cost-effective approach that would ensure full functional recovery without frequent therapy sessions. Manual passive ROM techniques combined with innovative mobilization orthotics<sup>19</sup> would not be suitable. The positive responses gained during intermittent therapy sessions could not be maintained because many hours of tissue elongation are needed to effect permanent tissue change.<sup>11</sup> Furthermore, there is no proven correlation between the application of passive motion and increased AROM in the chronically stiff hand.<sup>9</sup>

Regaining motion is known to be both a complex mechanical and cerebral

sensibility from the nerve injuries (see Fig. 5, Gantt chart, for the surgical procedures and treatment summary).

Cast design

The CMMS cast design is determined by the location of joint tightness and pattern of motion.<sup>9</sup> The position of the wrist is important as it must be actively extended and stabilized during digital flexion as this allows the flexor muscles to attain maximum functional length, permitting full finger flexion.<sup>20</sup> In the presence of a wrist flexion deformity, serial casting is necessary to restore wrist extension. This was achieved with the first 2 casts.

Initially, this patient had limitations in both flexion and extension of the metacarpophalangeal joint (MCPJ), PIPJ, and DIPJ. Mobilization of the PIPJ and DIPJ by initiating digital flexion with flexor digitorum profundus (FDP) and then flexor digitorum superficialis (FDS) into a hook fist position was prioritized over regaining MCPJ mobility as this encourages a normal pattern

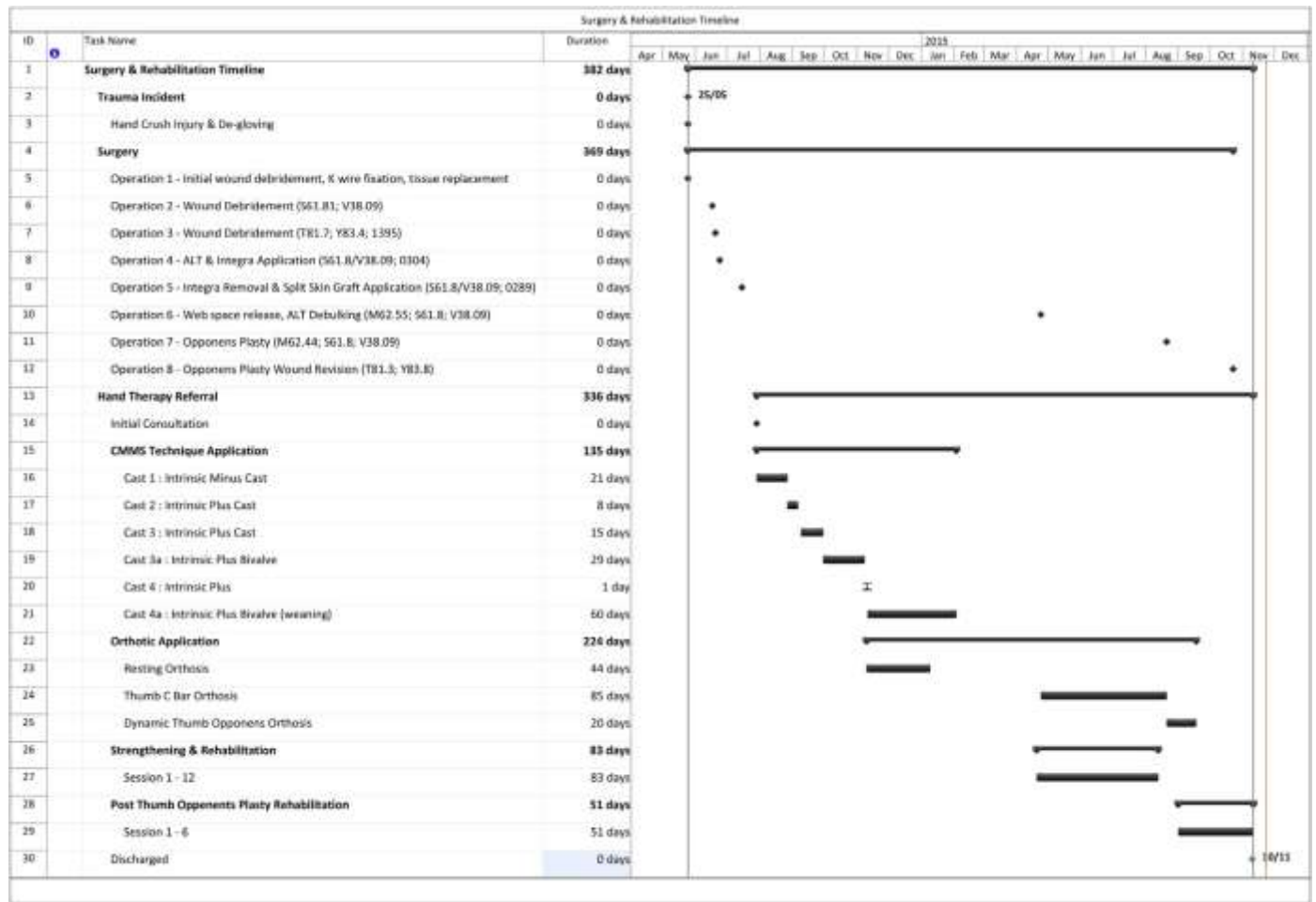


Fig. 5. Gantt chart.

challenge. The CMMS technique was considered the most appropriate method as it simultaneously addressed the problems of edema, fibrosis, extensive tissue adherence, and multiple joint stiffness. This was achieved through the application of a positive prolonged stress to the tissues while promoting normal sensory motor cortex repatterning, whereby finger flexion is initiated with the extrinsic finger flexors into an intrinsic plus position. This would occur by altering collagen cross linking, reducing tissue resistance, and subsequently mobilizing the stiff joints.<sup>9</sup>

The CMMS technique was initiated 8 weeks postsurgery and is referred to as baseline (Fig. 4). Care was taken not to apply the cast too tightly to avoid the development of a pressure injury, especially in the presence of diminished

of motion. This was achieved by positioning the MCPJs in maximum extension, which provides the optimal mechanical advantage for PIPJ mobility in both directions.<sup>9</sup> Maximum MCPJ extension was limited by ALT flap scarring at the base of the middle finger, which created a 50 flexion deformity of the MCPJ, which could not be corrected. Once interphalangeal (IP) motion improved and extrinsic flexor excursion was re-established, MCPJ mobility was prioritized by changing the cast design.

A nonremovable circumferential POP cast was applied to the forearm and hand positioning the wrist in maximum extension and the MPJs in maximum extension (Fig. 6, cast 1). This cast design is referred to as an intrinsic minus cast. The selective immobilization of the proximal joints, although constraining distal joints, facilitates the desired active motion of the digits actively over a long period.

Digital motion was poor as the FDP and FDS tendons could not glide across the stiff PIPJ and DIPJ. Normal digital flexion begins with the initiation of the FDP. This motion can be encouraged by placing a dorsal hood onto the cast that positions the DIPJs in relatively greater flexion than the PIPJs to facilitate initiation of flexion with the profundus muscle. Furthermore, the hood of the cast provides proprioceptive feedback to the fingers to initiate digital flexion at the DIPJ followed by the PIPJ. Flexion contractures of the PIPJs are avoided if care is taken to ensure that joint motion is facilitated in both directions.<sup>9</sup>

This initial cast design was worn for 4 weeks until full IP joint flexion could be achieved with the MCPJs in maximum extension.

Due to the presence of trauma to the dorsum of the hand and the subsequent development of tissue adherence, a second cast design was needed to resolve stiffness of the MPJs. This design involved placing the wrist in maximum passive extension (neutral) with a dorsal hood over the proximal phalanges that positions the MPJs in maximum passive flexion. This cast is referred to as an intrinsic plus cast (Fig. 5, cast 2). Cast 2 permitted full active motion of the PIPJs and DIPJs while encouraging active MCPJ flexion away from the hood (Fig. 7).

After 8 days, MCPJ flexion had improved significantly, and a third cast was needed that positioned the MCPJs in greater flexion but not at end range (Fig. 5, cast 3). Cast 3 was worn for 15 days before it was bivalved to be removable and enable personal care activities (Fig. 5, cast 3a). After MCPJ flexion improvements, a final cast was applied that positioned the MCPJs in greater flexion to achieve the final degrees of motion (Fig. 5, cast 4). This cast was bivalved 1 day later (Fig. 5, cast 4a) and worn intermittently for 60 days during the weaning phase of treatment to maintain improvements made in MCPJ flexion.

#### Cast exercises

In order for the motor cortex to learn a new pattern of motion and for long-term repatterning of the sensory motor cortex to be achieved and maintained, repeated digital motion in the desired pattern within the cast is needed over a prolonged period.<sup>9,11</sup>

The exercises included mobilizing the fingers actively and frequently into a hook fist within the intrinsic minus cast with regular rest periods and into a full fist within the intrinsic plus cast. The repeated cyclical motion of the fingers assists to reduce joint stiffness and restore a balanced pattern of motion in both the operated and nonoperated digits. The cast was reviewed and changed by the occupational therapist once ROM goals had been achieved.

The cast duration depends on 2 factors: the time required for new normal movement to be repatterned within the motor cortex and the time required for tight intrinsic muscles to reach their maximum length.<sup>9</sup> Cast weaning began when ROM goals had been achieved. The patient wore a bivalve cast intermittently during the day and reduced time spent in the bivalve cast over a 2-week period. The patient had to demonstrate the new desired pattern of motion within the cast for approximately 2 weeks and spontaneously demonstrate a normal tenodesis pattern out of the bivalve cast before its permanent removal.

#### Orthotic devices

Orthotic devices were used to improve finger extension and restore the first web space during the weaning phase of rehabilitation. A resting orthosis was applied at night to improve digital extension. Once digital extension was regained, a web space C-bar orthosis was applied at night to improve the thumb web space (Fig. 8). The patient was advised to wear the orthoses at night and continue to mobilize the fingers actively within the bivalve cast during the day. A dynamic thumb opposition orthosis (Fig. 9) was provided after an opponens plasty (Fig. 5, operation 7) to restore thumb opposition. This orthosis was worn for 4 weeks.

#### Therapeutic exercises

Once casting was discontinued, active and passive wrist mobilization exercises were used to improve wrist mobility. Thereafter, functional retraining and strengthening exercises, including mirror therapy, putty and resistance bands, were provided to improve functional hand use.



Fig. 6. Intrinsic minus cast.

#### Data collection

A standard goniometer was used to assess the affected digits AROM and recorded before, during, and after cast application. In addition, the pattern of active digital flexion was observed. Objective means of quantifying changes in movement patterns or soft tissue do not currently exist. Direct palpation is the only means of demonstrating the quality of soft tissue change.<sup>9</sup> Digital photography and video recording were used to assure that observations were accurately recorded.

#### Surgical procedures

The patient underwent 8 operations and was referred to hand therapy after the fifth operation. A web space release, opponens plasty and opponens plasty revision, was performed at 10, 16, and 18 months, respectively. The Gantt chart (Fig. 5) provides details of each operation.

The opponens plasty revision (operation 8) was required due to poor wound healing at the insertion of the FDS at the proximal phalanx of the thumb. The FDS was inserted more distally, and a split skin graft was applied to the defect. The revision surgery was successful.

#### Results

The patient attended 38 hand therapy sessions over 18 months (average ¼ 2.16 sessions per month). Functional improvements have been reported up until 18 months to demonstrate the effectiveness of the CMMS technique in

activities without feeling self-conscious. The ALT flap was debulked 8 months after the injury, which improved the cosmetic appearance.

Overall, the CMMS technique, and hand therapy plan resulted in functional



Fig. 7. Intrinsic plus cast.



Static Finger Extension Orthosis

Static Thumb C Bar Orthosis

Fig. 8. Orthotic devices.

maintaining AROM after additional surgical procedures. During the CMMS period, the patient did not report any difficulties with wearing the cast or implementing the exercises. The patient found it difficult to accept the disfigurement of his hand and wrist, but the cast enabled him to continue daily

improvements in the wrist, the MPJs of all fingers and the thumb, and all PIPJs and DIPJs. Most changes had the largest gains within the first 6 months of treatment while casting was taking place (Fig. 10). The improvements in finger flexion (Fig. 10) and finger extension (Fig. 11) were accompanied by improved sensation in the index and middle fingers (3.22-3.61),



Fig. 9. Dynamic thumb opposition orthosis.

resolution of trophic skin changes, and reduced fibrosis. The opponens plasty restored adequate thumb abduction and functional thumb opposition to the middle phalanx of the middle finger. However, the limited thumb opposition and its impact on function is reflected in the NRS-GF scores, where the patient feels that he has only achieved 50% of his full functional recovery after the opponens plasty.

#### Wrist ROM

The 30° flexion deformity of the wrist had resolved after the first 2 months of hand therapy, when 0° of extension was achieved. After 12 months, 20° of extension was achieved.

#### MCP joints

During the first 2 months of treatment, the anticipated 20–30° loss of MPJ flexion was observed in the index and middle fingers (Fig. 12). After 12 months of treatment, flexion and extension had improved substantially in all the fingers and thumb (Figs. 10 and 11).

#### IP joints

In both PIPJs and DIPJs, flexion and extension improved over the 12-month period and was maintained at 18 months (Fig. 13).

#### Total active motion

Substantial gains were achieved in terms of TAM, with the index, middle, ring, and little fingers increasing from 0, 2, 2, and 10, respectively, at baseline to 220, 200, 190, and 170 by 12 months (Fig. 4).

#### Functional ability

Functional ability of the whole person was measured using the ULFI-10, and functional impairment of the left upper extremity was assessed using the Biometrics E-Link. The ULFI-10 was completed at 3, 6, 9, 12, 15, and 18 months postinjury (Fig. 14). Functional impairment was calculated at baseline as well as 12 and 18 months after injury.

Overall, the ULFI scores increased from 0% to 55% of preinjury status (or capacity) over the 18 months of therapy. The functional impairment E-Link calculation improved from 85% at baseline to 38% at the 12-month follow-up assessment to 26% at the 18-month assessment.

At the start of hand therapy (baseline), the patient presented with a loss of intrinsic muscle bulk, ulnar nerve damage, edema, fibrosis, and multiple joint stiffness. Subsequently, he had no functional use of the hand with an ULFI-10 score of 10 of 10 and PSI of 0% function.

During the casting phase of rehabilitation (0–3 months), the focus was on facilitating a new movement pattern and motor cortex repatterning, mobilization of adherent tissue, and reducing joint stiffness. Functional retraining only was initiated once digital stiffness had resolved. During this time, the patient was only able to perform 40% of his preinjury (NRS-GF) duties by using his dominant hand only. From 3 months, functional retraining commenced. By 6 months, the ULFI-10 score improved to 8 of 10 (20% of preinjury status) and by 9 months the ULFI-10 score improved to 6 of 10 (40% of preinjury status).

At the 12-month assessment, the patient was recovering from the web space release (operation 6), and a reduction in functional ability was observed during this time. The ULFI-10 score reduced to 8 of 10 or 20% of preinjury status (Fig. 14). The NRS-GF remained at 40% of his preinjury duties between 3 and 12 months as he was unable to oppose his thumb, which was a severe functional limitation for him.



Fig. 10. Finger flexion results from the start of hand therapy (baseline).





Fig. 11. Finger extension results.

At the 18-month assessment, the patient had completed the final phase of his rehabilitation after an opponens plasty (Fig. 7, cast 3). The ULFI-10 improved to 4.5 of 10 or 55% of preinjury status. The PSI improved to 60% return of function, and the NRS-GF improved to 50% of his preinjury status.

#### Discussion

When the CMMS technique was originally described in 2002,<sup>11</sup> there were no studies comparing the effectiveness of POP casting with mobilization orthoses. In reality, opting for POP casting over the use of dynamic orthoses was probably occurring in clinical practice, but the choice was forgotten with the emergence of new materials and techniques in the use of mobilization orthoses. Today, the use of dynamic orthoses is by far the most commonly used

Since the description of the CMMS technique some 13 years ago, no randomized controlled trials or casecontrol studies have been undertaken to compare casting with the use of dynamic orthoses. To the author's knowledge, there has been only 1 paper focusing on the use of CMMS technique since its description: a case series involving 4 patients after Dupuytren's fasciectomy.<sup>21</sup> These patients presented with persistent multiple joint stiffness, edema, adherent scar tissue, and a dominant intrinsic flexion pattern of motion of the hand. These complications were initially managed using traditional therapy, but the desired outcomes were not achieved, and CMMS was used after conventional treatment failed. Use of CMMS for an average of 11 weeks after traditional treatment was successful in restoring digital motion and improving scar condition.<sup>19</sup>

The negative consequences of immobilization are well known, and this has led hand therapists to avoid managing soft tissue injuries by casting with POP unless it is a last resort in restoring motion. It must be noted that these unwanted effects occur only with prolonged immobilization. Loss of motion that occurs with brief casting is in 1 direction and temporary. Both surgeons and occupational therapists are hesitant to immobilize the MPJs in extension as conventional teaching has led to a fear of limiting flexion and causing further stiffness. Ironically, patients often welcome the technique as they feel secure and comfortable within the cast and can mobilize their stiff joints effectively. The transient loss of flexion must be accepted and then addressed after primary goals have been achieved. In this patient, the initial loss of flexion in MCPJs was quickly regained (Fig. 12), reinforcing that the advantages of the CMMS technique far outweigh the negative effects of temporary immobilization.<sup>11</sup>

It is the author's firm belief that this patient would not have achieved such dramatic results within the first 4 weeks of treatment with traditional therapy, even if he lived nearby and

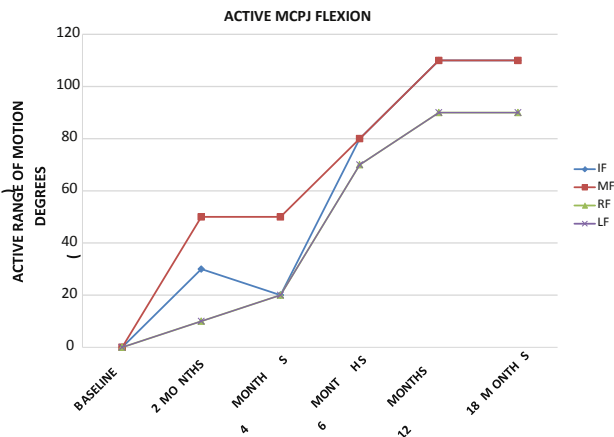


Fig. 12. Metacarpophalangeal joint (MCPJ) flexion results. IF ¼ index finger; MF ¼ middle finger; RF ¼ ring finger; LF ¼ little finger.

approach in managing soft tissue issues of the hand, whether traumatic or nontraumatic.

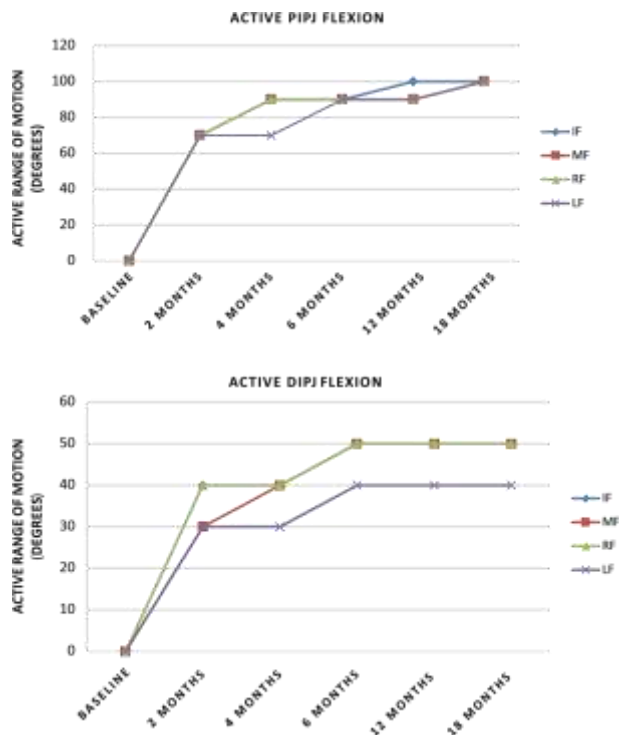


Fig. 13. Proximal interphalangeal joint (PIPJ) and distal interphalangeal joint (DIPJ) flexion results. IF ¼ index finger; MF ¼ middle finger; RF ¼ ring finger; LF ¼ little finger.

could attend weekly therapy sessions. This is because of the multitude of problems, which needed to be treated simultaneously. The CMMS technique provided the appropriate stress to the injured tissues and the sensory-motor input to regain function at both a mechanical and a cerebral level. Unfortunately, nerve damage resulted in poor thumb opposition, which marginally improved after an opponens plasty and ultimately resulted in the patient only regaining 50% of the functional use of the hand. Had the digital stiffness not resolved through the use of the CMMS technique, the functional loss would have been more devastating for the patient.

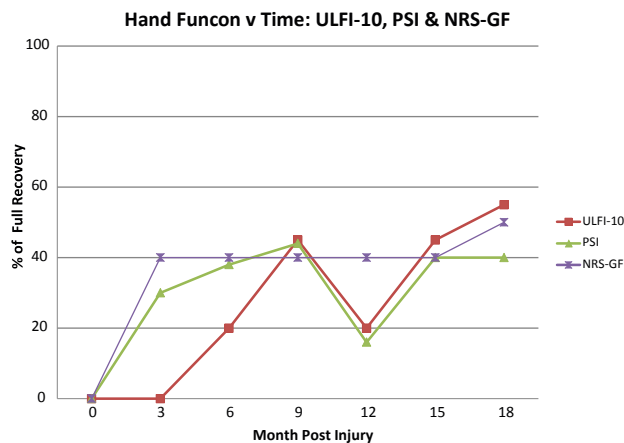


Fig. 14. Functional ability results. ULFI-10 ¼ upper limb functional index short form10; PSI ¼ patient-specific index; NRS-GF ¼ numerical rating scale of global function.

**Conclusion**

This case study documents the successful management of a degloving injury with multiple joint stiffness, edema, tissue adherence, and fibrosis

through the application of the CMMS technique. It is the author’s hope that this will encourage hand therapists to abandon previous assumptions about immobilization and use the POP casting and CMMS technique more readily in clinical practice. Further studies comparing traditional methods of treatment with the CMMS technique are needed to enhance evidence-based practice.

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## Quiz: #431

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- #1. The study design was
- case series
  - case report
  - RCTs
  - prospective cohort
- #2. The patient was involved in a vehicular accident and sustained
- a simple crush of the hand
  - 2<sup>nd</sup> and 3<sup>rd</sup> degree burns of the dorsum of the hand
  - multiple PIP fractures
  - a shoulder dislocation, multiple metacarpal fractures, and a thumb phalangeal fracture
- #3. The CMMS technique is an acronym for
- Cast Method to Manage Stiffness
  - Continuous Motion to Mobilise Stiffness
  - Casting Motion to Mobilise Stiffness
  - Controlled Motion to Mobilise Stiffness
- #4. While casted the patient was encouraged to apply \_\_\_\_\_ to the involved joints
- AROM
  - PROM
  - retrograde massage
  - MFR
- #5. The results suggest that CMMS was effective in this case
- true
  - false

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