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Original Article

Outcome of combined physiotherapy treatment with dynamic splinting in patient with traumatic hand injury: A case report

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Abstract
Introduction: Hands are highly susceptible to traumatic injuries, the treatment of which can often result in postoperative complications such as hand stiffness. This study reports the effectiveness of physiotherapy combined with dynamic splinting in managing traumatic hand injuries. **Problem Statement and Approach:** This case report features a 28-year-old male who sustained a traumatic injury in the third finger of his left hand. **Materials and Methods**: The patient was referred to the Physical Medicine and Rehabilitation Clinic at the University Clinical Centre of Kosovo, 11 weeks after surgery. Initial physical examination revealed that the hand was painful and swollen. There was also a partial disappearance of the lines of the palm, with redness and severe limitation in the movement of the wrist and fingers. Treatment began 11 weeks after the surgery and lasted for six months. Before commencing physiotherapeutic treatment, which consisted of electrotherapy, active/passive movement, scar management, mirror therapy, muscle strength exercises, coordination, and application of a dynamic splint to achieve a range of motion, hand assessment was done at the baseline after two, four, and six months. Pain was assessed using the verbal numerical scale (VNS) and the range of motion was measured using a goniometer. These values were presented according to Total active/passive motion (TAM Classification). Further, grip strength was assessed using the Jamar dynamometer. **Results:** Reduction in pain, and improvement in range of motion and muscle strength were observed. The pain reduced from 9 of 10 to 2 of 10; the total passive range of motion in the third finger increased from 30˚ to 160˚; the total active range of motion increased from 0˚ to 100˚; and the grip strength increased from 3.3 kg after two months to 14.5 kg, six months after injury. **Conclusion:** Following a traumatic hand injury, tailored combined physiotherapy treatment played a crucial role in restoring the functionality of the hand, by decreasing the pain, and improving the range of motion, muscular strength, and coordination.
Keywords: tendon and bone injury, joints stiffness, limited wrist and fingers movement, physical therapy

Introduction

Hands are an important component of the human body as they perform a unique function in the human body. Hence, they are synonymous with the human body's functioning and autonomy. Due to the exposure and extent of their function, they are at risk for traumatic injuries, such as fractures of bones and joints and injuries of tendons and nerves. These injuries can cause numerous clinical problems that often result in motor or sensory deficits, causing stiffness in the joints, limitations in movement, and pain. This can in turn lead to impairment of the function of the upper extremities, rendering the performance of daily activities impossible, and thereby have a negative impact on the quality of life (Dinesh & Karadawi, 2020; Cheung et al., 2013; Crane & Wimsey, 2022).

Serious injuries to the hands are often accompanied by chronic pain, which can cause anxiety and depression, consequently reducing the person's quality of life. Therefore, timely referral to a hand surgeon and physical therapist is crucial to ensure optimal results (Keller & Jordaan, 2022). Surgical management of any type of traumatic hand injury would be incomplete without physiotherapy treatment in the postoperative period (Karunadasa, 2015).

The restoration of function of the hand continues to be an important challenge in most cases of hand surgeries following traumatic injuries, due to prolonged immobilization and inadequate management. Several such cases have reported deficits in hand function and range of motion, and high level of pain (Rrecaj et al., 2014; Lee & Kim., 2019). In addition, some studies have shown that soft tissue damage, fracture, surgery, and prolonged immobilization can even lead to Complex Regional Pain Syndrome (CRPS) (Ratti et al., 2015; Beerthuizen et al., 2012; Roh et al., 2014). CRPS is a neuropathic painful disorder defined by the presence of allodynia, hyperalgesia, sudomotor, and vasomotor, as well as the appearance of trophic changes. CRPS causes pain disproportionate to the degree of tissue injury (Limerick et al., 2023; Dey et al., 2023). The most important treatment for CRPS is early rehabilitation, i.e., physiotherapy (exercises and electrotherapy) and occupational therapy (Limerick et al., 2023; Kanika et al., 2023).

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Increased knowledge about the anatomy of the hand, postoperative recovery, and rehabilitation have led to the development of new assessment techniques that can help improve the postoperative results for traumatic injuries of the hand (Ahmad et al., 2007). The success of surgical intervention following a traumatic injury of the hand greatly depends on the application of physiotherapy, which is a crucial factor in the treatment of patients. Physiotherapy is a multidisciplinary treatment that plays an essential role in the rehabilitation of the hand following traumatic injury and postoperative immobilization. Early physiotherapy following the surgery of a hand that has sustained traumatic injury is essential to prevent stiffness of the joints, development of contracture, and muscular atrophy, as it can help in promoting mobility, and improving the muscular strength, coordination, and function of the hand and upper extremity (Santacreu bet al., 2016; Glasgow et al., 2010; Sibtain et al., 2013).

Studies have proved the effectiveness of early application of physiotherapy procedures (electrotherapy and exercises) and splinting in the treatment of patients with musculoskeletal disorders or musculoskeletal injuries of the forearm, wrist, and hand. Considering the complexity of the hand and upper extremity, there is no evidence that strongly supports the use of only one physiotherapy procedure including splinting. This emphasizes the need for further research in this area to study the distinct value of physiotherapy combined with different treatment methods (Roll & Hardison, 2017).

The current study aimed to investigate the effectiveness of physiotherapy (electrotherapy, mirror therapy, and exercises) combined with dynamic splinting in decreasing pain, and restoring range of motion, muscular strength, and coordination following traumatic hand injury.

Case presentation

This is a descriptive case study that presents the treatment of a 28-year-old male from Pristina, who was referred to the Physical Medicine and Rehabilitation Clinic of the University Clinical Centre of Kosova on 14.02.2022 for physiotherapy treatment. The patient presented with a painful, swollen, and reddened left hand. The lines in his palm and fingers had partially disappeared and there was extensive limitation in the movement of the wrist and joints of the fingers. A scar was observed in the dorsal part of the hand, at the metacarpophalangeal (MCP) joint level of the third finger (Figure 1).

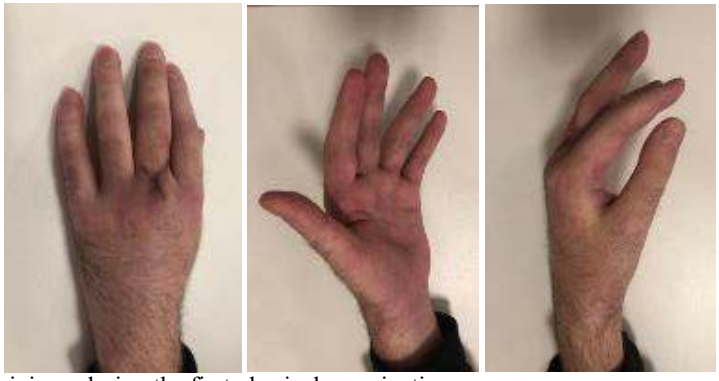

Fig.1. 11 weeks after injury, during the first physical examination

At the end of November 2021, the patient had met with an accident and was clinically diagnosed with a proximal phalanx fracture and extensor tendon rupture of the third finger of his left hand. He was treated surgically on the same day at the Emergency Center of the University Clinical Center of Kosovo. The fracture was fixed using a Kirschner wire by an orthopedist, while the extensor tendon repair was performed by a plastic surgeon, who recommended a plaster cast immobilization of the wrist and hand for eight weeks. During the first week of immobilization, the patient developed an infection in the injured area, which extended the immobilization period to 10 weeks. After these 10 weeks, the Kirschner wire and plaster were removed, and the patient was advised to consult a physiatrist and physiotherapist at the Physical Medicine and Rehabilitation Clinic of the University Clinical Centre of Kosova.

Material & methods

The physiatrist diagnosed the patient's condition as Complex Regional Pain Syndrome I (Harden et al., 2007) and recommended further physiotherapeutic treatment. After the physiatrist evaluation, the patient came to the Physical Therapy Department with his medical records and diagnosis described by the responsible orthopedic surgeon and physiatrist: Dg: St.post. VLC pars dorsalis et rupture muscle extensor dig. III, fractur proximal phalanges dig. III. mani lat sin., OP: Tendinorraphia muscle extensor, suture direct et fixation Kirschner wire prox. phalanges dig. III. mani lat sin.

Before enrolling the patient for physiotherapy treatment, he was evaluated by an experienced physiotherapist (SHM), who also implemented the physiotherapeutic treatment program. The evaluation was performed initially at 11 weeks after the surgery, and then at two, four, and six months post surgery. In the first physiotherapeutic assessment, the patient's sociodemographic and clinical data were studied, to assess the pain,

edema, allodynia, and active and passive range of motion. Grip strength was assessed two months after physiotherapy treatment using the Jamar dynamometer, by following the recommendations of the American Society of Hand Therapists (Bohannon et al., 2006).

Pain intensity during hand motion was assessed using the verbal numerical scale (VNS), which includes an 11-point numeric rating scale ranging from 0 to 10, in which 0 corresponds to no pain and 10 corresponds to severe pain (Ritter et al., 2006). Initially, the patient described the intensity of the pain as 9 of 10. Allodynia was assessed using a cotton-tipped tampon touching the skin of the hand (Ratti et al., 2015). The patient did not report any discomfort during this assessment. The circumference of the hand at the MCP joints was measured for edema assessment (Bell & Muller, 2013). The left hand was 2.0 cm more swollen than the right hand. The range of motion was measured using a standard goniometer for the wrist and a universal finger goniometer for the joints of all the fingers from I–V, and the results were presented according to the TAM classification (total active/passive motion) (Deniz et al., 2000; Pratt & Ball, 2016). The results indicated that the patient experienced extensive reduction in active and passive movements of the hand.

During the first physical examination, due to the limitations of the range of motion, we did not assess the patient's grip strength. Grip strength was measured only after two months of physiotherapeutic treatment using the Jamar dynamometer, as per the specifications of the American Society of Hand Therapists (Deniz et al., 2000). No questionnaire was used to assess the patient's quality of life. However, during the subjective examination before the treatment, during the treatment, and at the end of the treatment, the patient was asked if he could carry out the activities of his daily life. During the time of enrolment for the physiotherapeutic treatment, the patient reported that he was facing difficulties in performing daily activities, whereas after six months, he reported that he could use his hand properly.

After the first physiotherapeutic assessment, physiotherapeutic diagnosis conducted based on the ICF (International Classification of Function) revealed dysfunctions in the following areas: Mobility of several joints (b7101), Stability of joint functions (b715), Mobility of bone functions (b720), Power of isolated muscles and muscle groups (b7300), Power of muscles of one limb (b7301), Muscle tone functions (b735), Muscle endurance functions (b740) (Comprehensive_ICF_Core_Set_for_Hand_Conditions.pdf; Rudolf et al., 2012) of the left wrist and hand.

Physiotherapy treatment

The main goal of physiotherapy in combination with dynamic splinting is to eliminate or reduce pain, reduce edema, reduce the scar, restore passive and active movements in the affected joints, and restore muscular strength, coordination, and functionality of the hand, thereby enabling the use of the hand to perform daily activities. To achieve this goal, we used physiotherapy modalities such as electrotherapy, mirror therapy, sonotherapy, scar management, active/passive exercises of the wrist and joints of the fingers, muscular strength exercises, and coordination. In addition, we also used a dynamic splint by modifying it depending on the condition of the hand to achieve the desired range of motion.

During the first six weeks, the patient came to our clinic every day for physical therapy, except on weekends. From the 6th week to the 12th week, the patient presented himself at the clinic three times a week for physical therapy. From 12 weeks to 6 months, the patient visited the clinic one to two times a week for physical therapy. All this while, the patient continued the exercises and the recommended advice at home.

During the first two weeks of physiotherapy treatment, to improve edema, the patient was advised to perform hand elevation by keeping his hand in an elevated position for as much time as possible by supporting it on a pillow or cushion while sitting/sleeping, holding it up in an elevated position while moving around, and avoiding holding his hand down as much as possible. In addition, he was advised to do cryotherapy using ice packs for about 10 to 15 minutes, two to three times a day, and retrograde massage from distal to proximal direction for 10 minutes, at least twice or three times a day (Miller et al., 2017; Bell & Muller, 2013).

To relieve pain and increase local blood circulation, interferential therapy was administered once a day for 15 minutes for 10 days (Jarit et al., 2003). Electrotherapy was also given to reduce the pain level. In addition, the patient was also given mirror therapy for the wrist and fingers, three times a week for 20 minutes a day for one month (Rostami et al., 2013). Moreover, the patient was given passive mobilization in the wrist and finger joints of the affected hand three times a day for 10–20 repetitions.

After two weeks of treatment, interferential therapy was discontinued, and scar management was started using massage and passive/active movements of the wrist and fingers. This was accompanied by stretching of the dorsal part of the hand using an adequate force to enable movement in the MCP, PIP, and DIP joints of the fingers, with 10–20 repetitions. Ultrasound therapy (US) (1-MHz frequency; intensity of 1w/cm2) (Geetha et al., 2014) was applied to the scar once a day for 5 minutes for 10 days.

During the fourth to the eighth weeks of physiotherapy treatment, we continued with the same exercises and added assisted active exercises, wrist flexion/extension, ulnar/radial deviation, finger flexion/extension, abduction/adduction, opposition of the thumb, and forearm supination/pronation movements. In the eighth to twelfth weeks, in addition to the aforementioned exercises, "press and hold" exercises were recommended, while continuing sliding exercises and exercises to improve hand and forearm muscle strength (Evans, 2021; Roll et al., 2017; Keller & Jordaan, 2022). To increase the range of motion, we advised the patient to flex his fingers as

much as possible by pulling them using an elastic bandage, and to hold it for 5–10 minutes in the beginning, and then continuing the exercise by increasing the holding up time to 30 minutes (Figure 2).

Fig. 2. Elastic band and splint position after 6–10 weeks of physical therapy

Splinting

During the sixth week of physiotherapy treatment, a dynamic splint was used. The aim of splinting was to increase the range of motion of the fingers in flexion, to achieve movement in the MCP, PIP, and DIP joints. The splint was applied from the forearm at the level of the MCP joints by placing elastic tape on the fingers and pulling the fingers into flexion (Figure 2). After observing that the application of the splint was well tolerated, the patient was advised to use it for four weeks, initially holding it for 15 to 30 minutes a day and then continuing for 30 to 60 minutes a day. After the range of motion in the II–V MCP joints increased to 90°of flexion, the splint was modified and applied at the level of the PIP joints, by placing an elastic tape only on the third finger and pulling the finger into flexion (Figure 3) (Sibtain et al., 2013; Neuhaus et al., 2012; Maher et al., 2022). The patient was advised to apply the latter 2–3 times a day for 15–30 minutes. The patient is recommended to continue the exercise at home 2–3 times a day for 30–45 min.

Fig.3. Splint position from 11 weeks after physiotherapy application to 6 months

Ethical approval

This study was approved by the Research Ethics Committee of the Kosovo Chamber of Physiotherapists (Nr. 170) Pristina, Republic of Kosovo, and followed the ethical principles of the Declaration of Helsinki as revised in 2013. Written informed consent was obtained from the concerned patient.

Results

The outcomes of physiotherapy treatment, including pain score, total active and passive range of motion and grip strength, are presented in Table 1. Improvement was found in the active/passive movements of the wrist and the total active/passive movements of the fingers after two, four, and six months of physiotherapy treatment. We also observed improvements in grip strength. The pain measured by VNS decreased from 9/10 to 2/10, six months after physiotherapy treatment.

Table 1. Results of pain, range of motion from pre-treatment at two and four months and after six months, and grip strength at two, four, and six months after treatment

	Pre-treatment	**two months**	**four months**	**six months**
VNS	**9/10**	**6/10**	**2/10**	**2/10**
Wrist Joint (°)				
Flx	**A-10**	**A- 55**	**A-90**	**A-90**

	P-35	**P- 75**	**P-90**	**P-90**
Ext	**A-7** **P-15**	**A- 35** **P- 50**	**A-65** **P-70**	**A-70** **P-70**
Add (radial deviation)	**A-5** **P-10**	**A-10** **P-20**	**A-20** **P-25**	**A-25** **P-25**
Abd (ulnar deviation)	**A-7** **P-10**	**A-25** **P-30**	**A-40** **P-40**	**A-40** **P-40**
TAM - Thumb (CMC, MCP and IP joint)	**A-28** **P- 40**	**A-50** **P-120**	**A-125** **P-145**	**A-135** **P-145**
TAM - Digg-II-V (MCP, PIP and DIP joint)				
II	**A-45** **P-57**	**A-90** **P-145**	**A-110** **P-175**	**A-200** **P-230**
III	**A- 0** **P-30**	**A-20** **P-50**	**A-60** **P-115**	**A-100** **P-160**
IV	**A-25** **P-35**	**A-90** **P-120**	**A-130** **P-195**	**A-200** **P-215**
V	**A-30** **P-35**	**A-90** **P-125**	**A-133** **P-205**	**A-200** **P-225**
Grip strength (kg)				
Left hand		**3.3**	**9.1**	**14.5**
Right hand		**60.3**	**60.1**	**60.5**

A-Active; P-passive; Flx- Flexion; Ex- Extension; Add- ulnar deviation, Abd- radial deviation; TAM- total active motion; Flx- Flexion; Ex- Extension; CMC- carpometacarpal; IP- interphalangeal; MCP- metacarpophalangeal, PIP- proximal interphalangeal, DIP- distal interphalangeal; kg- kilogram.

Discussion

Inadequate management following traumatic wrist and hand injuries, including postoperative complications as well as prolonged immobilization, can cause serious complications such as pain and stiffness of the wrist and finger joints, obstructing movements and function of the hand. In some cases, it can even lead to CRPS, which is difficult to diagnose (Santacreu et al., 2016). If these complications occur, patients will not be able to use their hands in daily life activities, which can negatively impact their quality of life. In our patient, the development of complications might have been due to the long period of immobilization and infection of the interventional wound during immobilization. Studies have shown that combined physiotherapeutic treatment, including electrotherapy modalities, mirror therapy, exercises, and splinting, can improve hand function following various traumas and interventions (Wong, 2002; Saini et al., 2008; Wollstein et al., 2012).

In their study, Keller et al. (2022) presented the outcome of the management of traumatic hand injury, including scar massage, management of edema through pressure cuffs, active and passive joint mobilization, splinting, and home exercise program, showing a decrease in pain at the one-year follow-up. In our case study, the patient's pain decreased from 9/10 to 2/10 on the VNS, after six months of physiotherapy treatment. The difference between our study and the study by Keller et al. is that we also included mirror therapy in combination with other physiotherapeutic procedures. Although the effectiveness of mirror exercises on the basic mechanism of pain reduction is unclear, various studies have shown that mirror therapy has an impact on pain reduction. Ruud et al. showed that repeated use of mirror therapy helped to reduce pain in patients with causalgia (CRPS) of the hand associated with neuroma after peripheral nerve damage (Selles et al., 2008).

In addition to pain, limited movement of the wrist and finger joints is very common after traumatic injuries, and it is difficult to achieve good function; however, numerous studies have shown that physiotherapy, including exercises combined with splinting, improves hand mobility after injuries, surgery, and immobilization (Santacreu et al., 2016; Keller et al., 2002; Selles et al., 2008; Wollstein et al., 2012). Sibtain et al. (2013) reported that the combination of joint mobilization techniques with paraffin wax bath was more effective in improving pain, thumb function score, and passive range of motion of wrist flexion, extension, radial, and ulnar deviation when compared to mobilization techniques without combining with paraffin wax bath in the rehabilitation of the stiffness of the hand after traumatic injuries.

Santacreu et al. (2016) presented a case study in which a woman had sustained a fracture of the distal part of the radius, and following the surgery had four weeks of immobilization, developing stiffness in the joints of the hand. They reported that treatment combined with paraffin, manual therapy, prolonged active and passive stretch, and splinting showed reduction in pain, and improvement in mobility and functionality of the hand. Also, it is known that manual therapy allows the lengthening of short tissues by increasing the range of motion (Kaltenborn et al., 2011). Our study is in accordance with the findings of the aforementioned studies, as we have observed that the range of motion can be increased using passive and active mobilization, combined with elastic bands, rubber bands, and splinting. In addition to range of motion, grip strength is another important variable in determining hand function. In our study, we observed an improvement in grip strength after six months of

treatment (Figure 4), which is in line with other studies that reported improvement in grip strength after applying combined physiotherapy treatment (Santacreu et al., 2016; Kitis et al., 2012).

Fig. 4. Six months after physiotherapy.

Limitations

Patients who face complications following hand injuries cannot use their hands effectively in daily life, which can negatively affect their quality of life. We are aware that the use of an assessment instrument for assessing the quality of life is desirable. However, we did not use any questionnaire for the assessment, which we consider a limitation. Nevertheless, in our study, after six months of treatment, during subjective examination, the patient reported an improvement in hand use during daily life activities. Another limitation is that our study is a single case study. It would be valuable to conduct a larger study to confirm our findings.

Conclusion

Compared to other parts of the body, the hand is a complex anatomical organ which, due to its extensive use, is very often exposed to traumatic injuries. Such injuries often require surgical treatment and to achieve good results, surgical intervention should always be followed by physiotherapy and splinting.

Through our study, we have proved that detailed assessment of the different components of the hand is key to conducting successful treatment using different treatment approaches.

Therefore, we have used physiotherapy treatment in combination with dynamic splinting, which has shown reduction in pain, and improvement in range of motion, muscular strength, and coordination.

The most important clinical implication of this study is that tailored physiotherapy combined with dynamic splinting can provide very good results. Overall, our case shows that tailored physiotherapy treatment is essential to treat traumatic hand injuries. So, we strongly recommend proper physiotherapy assessment, as it will help us identify the appropriate physiotherapeutic treatment in combination with splinting, which can help patients achieve effective hand functioning to carry out the activities of their daily life without any hassles.

Statement of Informed consent: The patient has given written informed consent to publish this study.

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Conflict of interest: The authors state no conflict of interest.

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