An unusual example of complex wound care with physical therapy treatments – a case report

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Abstract

Background: Abnormalities in the healing process contribute to atypical scar formation, leading to consequences such as hypertrophic scars or keloids, pain, sensory disturbances, contractures, and other functional disorders. Additionally, the unsightly appearance of a scar can significantly impact the patient's mental health and overall quality of life. Various treatments exist to mitigate scarring and influence its integration, with combination therapies proving to be the most effective in addressing these multifaceted issues.

Aims: This paper aims to present a case study involving a patient with a post-traumatic hand scar who sought treatment at the Clinical Unit of Physiotherapy in the Clinical Mental Health Hospital in Rybnik, Poland.

Case Report: The study involved a 47-year-old man who experienced a work-related hand injury in August 2022. Over a span of six months, he underwent physical therapy modalities, hand exercises, and other therapeutic interventions three to five times a week. To assess the effectiveness of the interventions, measurements of the flexor muscles of the forearm were taken using a hand dynamometer before and after the therapeutic sessions. Notable improvements in wound healing, scar reduction, and muscle strength were observed following a series of treatments and exercises.

Summary: This case report underscores the effectiveness of complex wound care combined with physical therapy treatments in influencing scar formation. Nevertheless, further clinical trials are warranted to validate the efficacy of the proposed physiotherapeutic methods.

Key words

physiotherapy, wound management, scar, case study.

Introduction

Numerous factors can impede proper wound healing [1]. Consequences of impaired healing may manifest as hypertrophic scars or keloids, chronic pain, sensory disturbances, contractures, and functional disorders. Emerging research also indicates that psychological stress can adversely impact both wound healing and scar formation, both directly and indirectly [2]. It has been established that the risk of developing depressive disorders increases if a scar results in persistent discomfort and significant restrictions on mobility [3]. Beyond affecting everyday function and attractiveness, scar reduction plays a pivotal role in influencing psychological comfort, self-acceptance, and self-confidence. Optimal scar management is equally essential from a psychiatric perspective [4,5].

Comprehensive scar management encompasses both surgical and conservative methods. Conservative approaches include pharmacotherapy, physiotherapy (encompassing physical therapy, exercises, massage, and specialized physiotherapeutic methods), as well as procedures in medical cosmetology and aesthetic medicine (such as ablative fractional laser, platelet-rich plasma injections, fractional radio frequency micro-needling, micro-needling, chemical peels, microdermabrasion, and others) [6-9]. Notably, combined therapies have proven to be the most effective in achieving optimal outcomes [10].

A recent and innovative development in wound care technology encompasses nanotherapeutics, stem cell therapy, bioengineered skin grafts, 3D-bioprinted skin, extracellular matrix-based approaches, and cold plasma treatment therapy [11]. Physiotherapeutic wound and scar management primarily center around conservative modalities.

These treatments can be categorized into manual therapy and specialized physiotherapeutic methods, as well as physical modalities such as mechanotherapy, electrical therapy, electromagnetic fields, light therapy, and their various combinations [12-15]. There is preliminary evidence suggesting that dry needling may also contribute to wound healing and impact scar appearance [10,16,17].

Aims

This study aimed to outline the therapeutic approach employed for a patient with a post-traumatic hand scar seeking treatment at the Clinical Unit of Physiotherapy in the Clinical Mental Health Hospital in Rybnik, Poland. The primary objective of physiotherapy was to maximize hand function and enhance the appearance of the scar. Specifically, the initial goal was to mobilize and restore flexibility, achieving complete palmar flexion, and regaining optimal muscle strength, with a focus on the forearm flexor group, within the initial two months. Subsequently, the therapy shifted towards improving superficial sensation and promoting blood circulation in both the scar and the surrounding tissues.

Case report

A 47-year-old male patient experienced a work-related accident on August 30, 2022. The wound resulted from a crush injury and laceration to the right hand, specifically involving a pullout and damage to the extensor staple of the right phalanx of the second finger, along with a subcondylar open fracture of the fifth metacarpal bone (**Fig. 1**). Upon examination, significant swelling was evident, necessitating wound debridement. The wound underwent surgical treatment, involving the suturing of the stump of the extensor proper with the common extensor of the fingers. Additionally, stabilization of the fracture of the V metacarpal bone was achieved using two Kirschner wires. The surgical procedure took place during the night of August 30-31, 2022, and the patient was subsequently referred for further outpatient treatment (**Fig. 2**).

The patient was readmitted to the hospital unit on September 3, 2022, suspecting an infection in the surgically treated tissues following the reconstruction of the right hand (**Fig. 3-4**). Intravenous antibiotic therapy was initiated, and the patient was subsequently referred for further outpatient treatment (**Fig. 5-6**).

Figure 1. Post-traumatic hand condition.

Figure 2. Hand condition after surgery.

Figure 3. Hand condition before debridement.

Figure 4. Hand condition before debridement.

Figure 5. Hand condition after debridement.

Figure 6. Hand condition after stitches removal.

Upon admission to the Clinical Unit of Physiotherapy on December 20, 2022, the patient reported significant flexion restriction, evident hand dysfunction, and impaired scar healing. The patient had no history of chronic diseases but had been diagnosed with and treated for vitamin D3 deficiency (18 ng/ml) on November 18, 2022, and had an ongoing nicotine addiction. Physical therapy treatments were administered from December 21, 2022, to July 15, 2023, with a one-month break in May. The detailed treatment methodology is outlined in **Table 1**.

Before the intervention, the scar exhibited maturation, characterized by convex hypertrophic features in the proximal and central regions and atrophic features in the distal areas. Post-inflammatory/traumatic discoloration was evident, accompanied by persistent edema within the palms of the hand (**Fig. 7**). The patient's skin was dry and scaly. Palpation assessment revealed heterogeneity in the scar's course. While some parts maintained satisfactory mobility, other sections showed complete immobilization of the soft tissues. Numerous subcutaneous adhesions within the soft tissues contributed to a significant limitation of palmar flexion and weakened muscle strength. A noticeable discrepancy in muscle strength was observed in the flexor muscles of the forearm, resulting in a -6 kg difference in grip strength between the healthy and injured limbs (45.7 kg and 38.4 kg, respectively), as measured in a hand grip test using a hand dynamometer.

During the initial 1-2 months, the therapeutic approach involved manual lymphatic drainage and lymphatic taping of the upper limb (**Fig. 8**). The patient received comprehensive instructions for skin and scar care to be continued at home. To augment the impact of manual therapy, physical therapy modalities were introduced. These included phonophoresis treatments using Contractubex® gel, biostimulation laser therapy (Low-Level Laser Therapy; LLLT; 660 nm, 500 mW, 12-15 J/cm^2), and low-frequency magnetic field therapy (MT; 5 mT, 20 Hz, 40-45 min.). These treatments were conducted in series, with 20 sessions each for phonophoresis and laser therapy, and 15 sessions for the low-frequency magnetic field. Notably, the interventions resulted in an increased range of motion (ROM) and reduced swelling. Subsequent to this phase, mobilizations with movement were incorporated, and the patient was advised to perform hand exercises independently at home, 3-4 times a week for 25 minutes each. These exercises involved eccentric work of the wrist and finger extensors, utilizing a 3.5 kg weight held in the hand. Kinesiotaping applications were also integrated into the therapy (**Fig. 9**).

Figure 7. Hand condition on the day of admission.

Table 1. Detailed treatment methodology based on the literature [10, 12-18].

Month 1	Month 2	Month 3	Month 4	Month 5-6
Manual lymphatic drainage – 20 treatments in a series	Mobilizations with movement, fascial and manual therapy - 2 times a week for approx. 45 minutes	Fascial and manual therapy - 2 times a week for approx. 45 minutes	1-month break from treatments	Fascial and manual therapy - 2 times a week for approx. 45 minutes
Lymphatic taping – 1 application for 3-5 days	Kinesiotaping– 1 application for 3-5 days	Lymphatic taping and cross-taping		Dry needling – once a week
Phonophoresis with Contractubex® gel – 20 treatments in a series[5]	Phonophoresis withwith direct current (0.1 mA/cm^2), with Contractubex® gel– 20 treatments in a series[5]	NMES, 5 times a week, once a day for 20 minutes in series of 20 each[3]		HVES[4]
LLLT – 20 treatments in a series[1]	LLLT – 20 treatments in a series[1]	LLLT – 15 treatments in a series[1]		US[5]
MF – 15 treatments in a series[2]	MF – 15 treatments in a series[2]	MF – 15 treatments in a series[2]		Kinesiotaping– 1 application for 3-5 days
Hand exercises at home, 3-4 times a week, 25 minutes each, scar mobility exercises and proper skin treatment	Hand exercises at home, 3-4 times a week, 25 minutes each, 3.5 kg weight	Hand exercises at home, 3-4 times a week, 25 minutes each, 3.5 kg weight	Fine motor skills exercises and eccentric and concentric exercises of the wrist extensors, 3-4 times a week for 25 minutes each, independently at home	Active exercises with virtual reality-based feedback (Microsoft Kinect® device with VAST. Rehab® software), 2 times a week for 25 minutes

Legend: ***(1)*** *Low-Level Laser Therapy (LLLT) methodology: The laser probe, utilizing a wavelength of 660 nm with a continuous emission of 500 mW, was applied to the scar. The probe was positioned perpendicular to the skin and in direct contact with it, delivering a dose of 12-15 J/cm^2. Each probe application lasted for 30 seconds.* ***(2)*** *Magnetic Field (MF) methodology: The induction level was set at 5 mT, with a frequency of 20 Hz during the application on the scar. The treatment duration was 40-45 minutes.* ***(3)*** *Neuromuscular Electrical Stimulation (NMES) methodology: Electrodes were strategically placed at the beginning and end of the forearm muscle bellies for application in the forearm area. The alternating current had a frequency of 2500 Hz, modulated in a rectangular shape to modules with a frequency of 40 Hz. The duration of the muscle contraction modules was 2 seconds, with a break between modules (muscle relaxation) lasting 4 seconds. The total treatment duration was 20 minutes.* ***(4)*** *High Voltage Electrical Stimulation (HVES) methodology: The treatment electrode (cathode) was applied to the scar using sterile gauze pads. Twin-peaked monophasic pulses were administered with a total duration of 100 µs, a frequency of 100 Hz, and a voltage exceeding 100 V. The amperage (intensity) was set at the sensory level, and the treatment lasted 45-60 minutes.* ***(5)*** *Ultrasound (US) methodology: The ultrasound probe, operating at a frequency of 3 MHz, was applied to the scar on the back of the hand. The spatial average temporal peak was 0.5 W/cm^2, with a duty cycle of 50%. The spatial average temporal average was 0.25 W/cm^2, and each application covered 40 seconds per 1 cm^2. The total treatment time approximated 20 minutes.*

Figure 8. Lymphatic Kinesiotaping application.

Figure 9. Kinesiotaping application on the scar.

Over the subsequent 3-4 months, the therapeutic approach continued with fascial and manual therapies. Despite having achieved a full range of palmar flexion, residual adhesions in the soft tissues and a decrease in hand tightness persisted. An electromyography (EMG) evaluation conducted on May 26, 2023, identified sensory-motor neuropathy of the median nerves. Consequently, neuromuscular electrical nerve stimulation (NMES) was integrated into the therapy plan, targeting the flexor muscles of the forearm. NMES involved the use of alternating current with a frequency of 2500 Hz, modulated into rectangular modules at 40 Hz. Each module comprised a 2-second muscle contraction followed by a 2-second break for muscle relaxation. This NMES approach, often referred to as Russian electrostimulation or Kotz electrical stimulation, utilized carbon rubber electrodes (6x8 cm; 48 cm^2) placed on wet gauze pads along the muscle fibers' course at the beginning and end of the muscle belly. NMES sessions were conducted five times a week, once a day, for 20 minutes in series of 20 each. Cross-taping (**Fig. 10**) and lymphatic-taping applications were also included. At the end of the fourth month of therapy, nearly a full ROM of palmar flexion was achieved. A retest of the strength of the flexor muscles of the forearm using a hand dynamometer showed a difference in compression strength between the healthy and injured hand of -4 kg (44.9 kg and 40.7 kg, respectively). Additionally, improvements were noted in the skin condition and visual appearance of the scar, with a reduction in the hypertrophic part of the scar in the proximal and middle regions.

After the initial 4 months of therapy, a planned one-month break from the aforementioned treatments was implemented. During this period, the patient received a recommendation to persist with fine motor skills exercises, as well as eccentric and concentric exercises of the wrist extensors independently at home, 3-4 times a week for 25 minutes each. In the subsequent 5-6 months of therapy, the focus shifted towards enhancing blood supply to the scar and surrounding tissues, improving superficial sensation, and further increasing muscle strength. To achieve these goals, the treatment plan incorporated manual scar therapy, dry needling treatment (**Fig. 11**), cathodal high voltage electrical stimulation (HVES),

Figure 10. Cross-tape application.

and sonotherapy. These treatments were administered 2-3 times a week, with dry needling performed once a week, resulting in a total of 3 treatments per week on an alternating basis.

Sonotherapy was conducted using ultrasound (US) with a frequency of 3 MHz. Intermittent US emission with a duty cycle of 50% was applied, utilizing an average spatial average temporal peak (SATP) power of 0.5 W/cm^2. With a 50% duty cycle, this resulted in an average spatial average temporal average (SATA) power of 0.25 W/cm^2. These US parameters were chosen to avoid thermal effects. The treatments utilized an ultrasonic head with transmitting surfaces of 3 and 5 cm^2. The duration of the treatment was 40 seconds/cm^2 of the sonicated surface, equivalent to 40 seconds per treatment area corresponding to the surface of the US head. As the treatment field was larger than the surface of the US head, the head was moved on and around the scar, leading to a total treatment duration of approximately 20 minutes. The US head was applied 5-6 times to the treatment site, and the treatments were performed once a day, five days a week, for two weeks, totaling 20 procedures.

High Voltage Electrical Stimulation (HVES) utilized carbon rubber electrodes (6x8 cm; 48 cm^2) placed on sterile gauze soaked in saline. The therapeutic electrode (cathode) was positioned on the scar's surface, while the electrode averting the electrical circuit was fixed in the shoulder area, over the biceps muscle of the arm. Dual monophasic pulses were administered, with a total duration of 100 μs and a frequency of 100 Hz. The current flowed at a voltage > 100 V and was adjusted to produce minor sensory impressions. The duration of HVES varied from 45 to 60 minutes (gradually increased in a series of treatments). Treatments were performed once a day, five days a week, for two weeks, totaling 20 HVES procedures.

During the 5th and 6th months, Neuromuscular Electrical Stimulation (NMES) was discontinued, and active exercises with virtual reality-based feedback, using the Microsoft Kinect® device with VAST.Rehab® software (**Fig. 12**), were introduced. These exercises occurred twice a week, lasting 25 minutes each. The hypertrophic part of the scar in the proximal and middle regions saw a significant reduction, accompanied by improved skin appearance (**Fig. 13-14**).

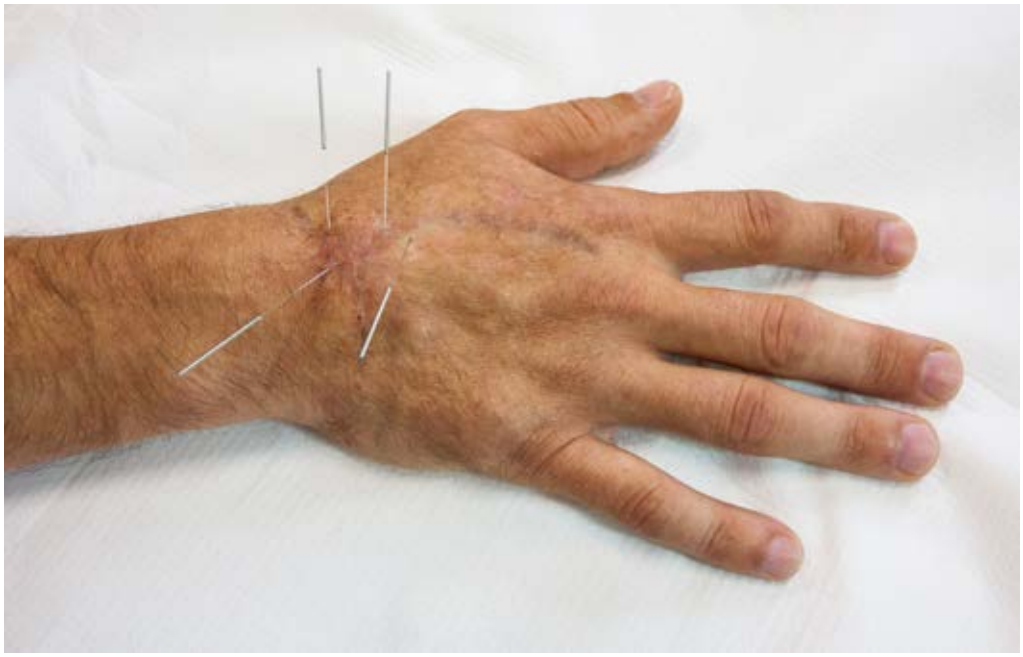

Figure 11. Dry needling of the scar.

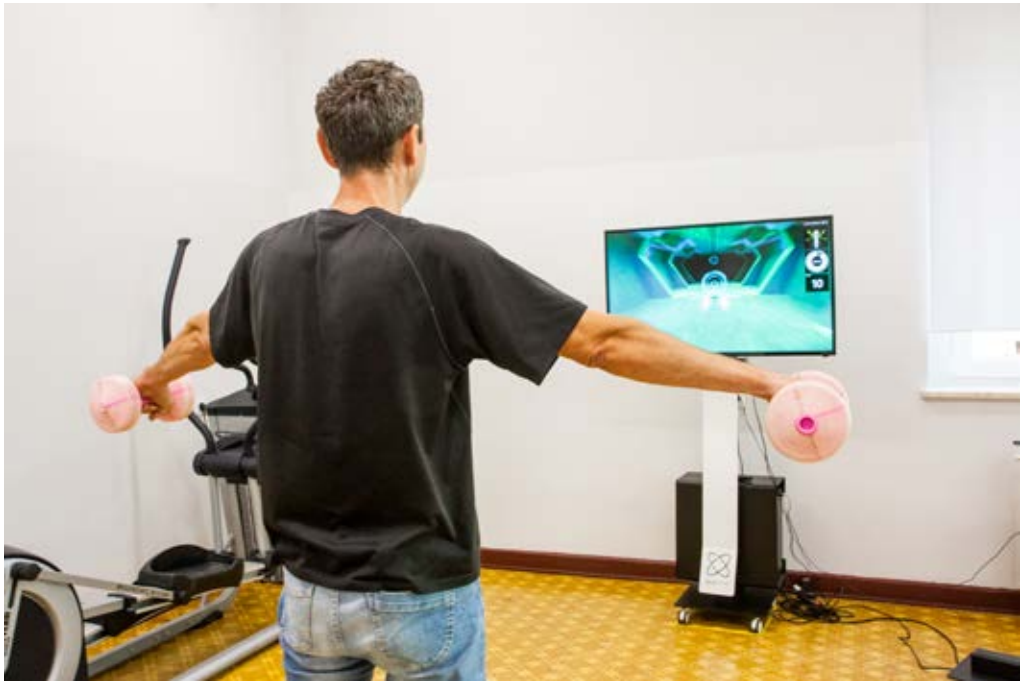

Figure 12. Virtual reality (VR) based exercises.

Figure 13. Hand condition after 5 months of therapy.

Figure 14. Hand condition after 6 months of therapy.

Physiotherapy was successfully concluded in the 6th month after admission, resulting in a remarkable enhancement in hand function and an improved appearance of the scar (**Fig. 15**). The scar exhibited a flatter, brighter, and more flexible profile. Fine mobility along the scar's course was restored, with only a few subcutaneous adhesions within the soft tissues. The skin surrounding the scar became more hydrated and elastic, visibly reducing post-traumatic and post-inflammatory discoloration. Additionally, the strength of the forearm muscle normalized. In a hand grip test, the difference in grip strength between the healthy and injured limb was -2.6 kg (44.3 kg and 41.7 kg, respectively). The patient was advised to continue therapy further to enhance the scar's appearance, with a recommendation to explore aesthetic medicine clinics. If deemed necessary, treatments purely focusing on skin remodeling and scar color could be pursued. Common therapies in this domain include ablative fractional laser or bromide-copper laser therapies, platelet-rich plasma injections, fractional microneedle RF treatments, chemical peels, and their various combinations.

Figure 15. Hand condition at the end of therapy.

The patient exhibited good tolerance and responded positively to the provided treatment. Both the appearance of the scar and hand function showed significant improvement. No adverse symptoms were observed following dry needling and physical treatments. Furthermore, there were no reported allergic reactions to the acrylic adhesive, and no instances of skin irritation were observed after patching.

Discussion

Guidelines and recommendations for managing chronic wounds are extensive, encompassing patient compliance with doctor's advice, infection prevention, proper wound care, and intermittent pneumatic compression treatments [19, 20]. Appropriately selected physical therapy modalities play a crucial role in supporting the wound healing process across all phases [15]. Physiotherapeutic treatments can be primarily categorized into therapeutic procedures for chronic wounds and scars [15].

In the systematic review with meta-analysis conducted by Deflorin et al. [12], the objective was to determine the effects of physical treatments on scar pain, pigmentation, pliability, pruritus, scar thickening, and surface area in adults with various types of scars. The analysis included 13 studies on burn scars, 5 studies on post-surgical scars, and 1 study covering all kinds of hypertrophic and keloid scars. Intervention methods were categorized into mechanotherapy (massage and extracorporeal shockwave therapy – ESWT), occlusion and hydration therapy (silicone application, moisturizing cream, etc.), and light therapy (pulsed dye laser – PDL, and high-intensity light therapy – HILT). Particularly notable is the use of ESWT, which, according to recent studies, enhances the range of movement and scar tissue remodeling [21]. This meta-analysis [12] indicates that physical scar management has a significant positive effect on pain (ESWT, massage, as well as HILT,

p = 0.012), pigmentation and pliability (PDL and silicone gel, p = 0.010), pruritus and surface area (PDL and CO_2 laser, p = 0.010), and scar thickness (massage, p = 0.022) compared to the control or no treatment. In our study, massage, low-level laser therapy, and moisturizing treatments (proper home care) also resulted in improvements in scar thickness and hand function.

In another study conducted by Freitas et al. [22], 17 volunteers were randomly assigned to an experimental group (EG; n=9) and a placebo group (PG; n=8). The volunteers were stratified by the age of their scars into four groups: Group 1: < 6 months (17.6%), Group 2: 6–12 months (17.6%), Group 3: 12–24 months (29.4%), and Group 4: >24 months (35.6%). 58.8% of the scars were located on the trunk, and 41.2% were on extremities. The parameters for low-level laser therapy (LLLT) were as follows: a laser probe without contact with the skin (approximately 1 cm from the skin surface), perpendicular to the skin throughout the scar, and with a punctual application maintaining a distance of 1 mm between each point. The wavelength was 808 nm with continuous emission of 500 mW, and the dose was 4 J/cm^2. The treatment time consisted of 4 seconds per probe application. Fifteen sessions were conducted for both groups three times a week, with the laser device switched off in the PG. After 5 weeks of LLLT treatment, the EG exhibited a significant improvement in macroscopic scar appearance (p = 0.003) and a tendency to decrease scar thickness. In our study, we also observed a reduction in scar thickness, albeit using a different wavelength (660 nm), a contact probe method, and a different dose (12-15 J/cm^2). Additionally, we performed a greater number of treatments to achieve satisfactory results.

In another scoping review conducted by Scott et al. [23], the objective was to assess the effectiveness of massage as an intervention in the treatment of postoperative scars. Various clinical databases (Medline, EMBASE, CINAHL, AMED, Scopus, ProQuest Dissertations & Theses Global, and the Joanna Briggs Institute) were searched, resulting in the inclusion of 25 studies in the review. Only two papers, involving 92 participants, specifically addressed hand or wrist scars with scar massage performed alongside standard conjunctive therapies.

While all studies reported favorable outcomes for scar massage, there were notable differences in research methods, outcome measures, and intervention protocols. Intervention protocols ranged from a single session to three treatments daily for 6 months. The overall findings of the scoping review suggest that scar massage may be beneficial in increasing ROM and improving scar appearance; however, further studies are deemed necessary. In our study, we conducted both manual lymphatic drainage and scar massage with musculofascial manual therapy, twice a week for approximately 45 minutes each day over a 6-month period. Despite Polish and global guidelines mentioning compression therapy and intermittent pneumatic compression treatments [19, 20], there is insufficient scientific evidence for their effectiveness in cutaneous linear hand scars. The authors of this case report believe that combined therapies will prove to be the most effective approach.

Limitations of the study

The case study has some potential limitations. To ascertain the effectiveness of the proposed physiotherapeutic methods, further studies on a larger cohort of patients are essential. The impact of reducing vitamin D deficiency on wound healing was not determined in this study. Additionally, we did not ascertain which specific physiotherapeutic method played a crucial role in stimulating healing, although we observed accelerated improvement in scar appearance following HVES stimulation and dry needling. ROM was not measured with a goniometer, and while the patient expressed satisfaction with the obtained results, the study did not measure improvements in patient satisfaction or quality of life. Utilizing a simple tool to assess these areas in future studies would provide valuable insights.

Summary

The aim was to achieve the highest possible improvement in hand function, focusing particularly on achieving full palmar flexion and enhanced muscle strength, along with improving the appearance of the scar. The implementation of physical therapy modalities, hand exercises, and other therapies conducted three to five times a week over a 6-month period resulted in significant improvements in the patient's physical, psychological, and overall comfort. It is important to note that despite the availability of numerous therapeutic tools and methods, complete scar removal was not attainable. It is crucial to recognize that the recommendations and outcomes presented are specific to this study and are based solely on the methodology employed here. Therefore, further clinical trials are imperative to validate the effectiveness of the proposed physiotherapeutic methods.

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