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Effect of Ultrasound and Exercise Therapy on Pain After Dorsal Hand Flap: A Case Report

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Abstract

Background: Functional impairment following dorsal hand skin flap reconstruction commonly presents with pain, stiffness, and limited range of motion, which may interfere with daily activities, particularly in the chronic phase.
Objective: This study aimed to evaluate the effectiveness of ultrasound and exercise therapy in reducing pain and maintaining functional capacity in a patient with chronic post-operative hand contracture.
Methods: This case report was conducted in accordance with the CARE guidelines. A 27-year-old male with flexion contracture of the fourth and fifth proximal interphalangeal joints following dorsal hand flap reconstruction was treated at an orthopedic rehabilitation hospital in Surakarta, Indonesia. The intervention was administered once weekly for three weeks and included therapeutic ultrasound (continuous mode, 5 minutes), scar massage, active exercise, and activities of daily living training. Outcomes were assessed using the Numeric Rating Scale (NRS), goniometry, Manual Muscle Testing (MMT), limb circumference, and Wrist Hand Disability Index (WHDI).
Results: Movement-related pain decreased from 4/10 to 2/10, indicating a clinically meaningful improvement. Resting and pressure pain remained at 0/10. Muscle strength (MMT 3/5), range of motion (PIP flexion 45°–50°), limb circumference, and WHDI score (10%) showed no changes.
Conclusion: A short-term physiotherapy program may contribute to pain reduction and maintenance of functional status in chronic post-surgical hand conditions. However, it appears insufficient to improve muscle strength, range of motion, or overall functional outcomes, suggesting the need for longer and more intensive rehabilitation strategies.

Keywords
Hand, Surgical Flaps, Ultrasonic Therapy, Rehabilitation, Contracture

Introduction

The hand plays a fundamental role in daily human activities, encompassing grasping, pinching, object manipulation, fine motor coordination, and sensory integration. Any impairment in hand function due to trauma, injury, or surgical intervention can significantly compromise an individual's ability to perform activities of daily living (ADLs), reduce independence, and negatively affect quality of life.[1] In clinical practice, injuries involving the dorsum of the hand are particularly challenging due to the thin soft tissue coverage and the presence of critical anatomical structures such as tendons, bones, and neurovascular components.[2] Consequently, extensive soft tissue defects in this region often require reconstructive procedures to restore both structural integrity and functional capacity.[3]

Skin flap reconstruction is a widely used surgical technique for managing complex hand defects, particularly when primary closure or grafting is not feasible.[2] A flap is defined as a unit of tissue transferred from a donor site to a recipient site while maintaining its own vascular supply, thereby enabling survival and integration at the new location.[4] Advances in reconstructive surgery have improved flap survival rates; however, successful outcomes are not solely determined by tissue viability but also by the restoration of hand function, including mobility, strength, and coordination.[1,5] Despite these surgical advancements, postoperative complications such as pain, joint stiffness, adhesions, and contractures remain common, especially in cases involving prolonged immobilization or delayed rehabilitation.[1]

In the chronic phase following flap reconstruction, the presence of mature scar tissue and structural changes in periarticular tissues often limits the potential for rapid functional recovery. These conditions are frequently associated with flexion contractures, reduced range of motion (ROM), and persistent discomfort during movement.[1] From a rehabilitation perspective, physiotherapy interventions in this phase are primarily aimed at pain modulation, maintenance of existing function, and prevention of further deterioration rather than complete restoration of normal function.[6] Therapeutic modalities such as ultrasound, scar management techniques, and exercise therapy are commonly employed to address these impairments. However, their effectiveness in chronic post-flap conditions remains a subject of ongoing investigation.[7]

Therapeutic ultrasound has been proposed to facilitate tissue healing and pain reduction through thermal and non-thermal mechanisms, including increased blood flow, enhanced tissue extensibility, and modulation of inflammatory processes.[8] Meanwhile, exercise therapy, particularly active and functional exercises, plays a central role in maintaining joint mobility, improving neuromuscular control, and supporting functional independence.[6] In addition, activity-based interventions such as ADL training are essential in promoting the practical use of the affected hand in real-life contexts, even when structural limitations persist.[9] Despite the theoretical benefits of these interventions, current evidence regarding their combined effectiveness in chronic cases of dorsal hand flap reconstruction remains limited and inconclusive.[10]

A review of the existing literature indicates that most studies on post-flap rehabilitation focus on acute or subacute phases, with relatively few reports addressing long-term functional outcomes in chronic conditions.[1,2] Furthermore, there is a lack of detailed

clinical reports describing the response to physiotherapy interventions in patients with established contractures following dorsal hand reconstruction. This gap highlights the need for clinically relevant case reports that provide insight into realistic rehabilitation outcomes, particularly in settings where complete functional recovery may not be achievable. However, evidence regarding the effectiveness of physiotherapy interventions in the chronic phase following dorsal hand flap reconstruction remains limited, particularly in cases with established contracture. This highlights the need for clinically detailed case reports to provide practical insights into realistic rehabilitation outcomes in chronic conditions.

Therefore, this case report aims to evaluate the effectiveness of ultrasound and exercise therapy in reducing pain and maintaining functional capacity in a patient with chronic flexion contracture following dorsal hand skin flap reconstruction. By documenting the clinical course and outcomes of this intervention, this study seeks to contribute to the existing body of knowledge and provide practical insights for physiotherapists managing similar cases in clinical settings.

Methods

This study employed a single-patient case report design and was developed in accordance with the CARE (CAse REport) guidelines to ensure completeness, transparency, and clinical relevance treated at an orthopedic rehabilitation hospital in Surakarta, Indonesia. The case report approach was selected to provide an in-depth description of the patient's clinical presentation, intervention process, and outcomes in a real-world clinical setting, particularly in the context of chronic post-surgical hand rehabilitation, where evidence remains limited.

The subject was a 27-year-old male diagnosed with flexion contracture of the right fourth and fifth proximal interphalangeal (PIP) joints following dorsal hand skin flap reconstruction. The patient sustained a traumatic injury in March 2024 due to a traffic accident, resulting in fractures and an open wound on the dorsal aspect of the right hand, requiring reconstructive surgery using a skin flap technique. The patient worked as a manual laborer, which required frequent use of hand function in daily activities.

Following surgery, the patient experienced persistent difficulty in finger flexion, incomplete grip formation, and pain during stretching movements. These limitations interfered with fine motor tasks and certain activities of daily living. The patient was in the chronic phase of rehabilitation at the time of intervention, characterized by mature scar tissue and established joint stiffness.

The patient was selected for this case report based on clinical relevance, specifically the presence of persistent functional limitations after flap reconstruction despite standard postoperative recovery. Risk factors for post-operative hand contracture include prolonged immobilization, severity of soft tissue injury, intra-articular involvement, post-operative edema and pain, and delayed initiation of rehabilitation. Furthermore, patient-related factors such as poor adherence to therapy and complications including infection may further increase the risk of contracture.

A comprehensive physical examination was conducted to evaluate the patient's condition. Inspection revealed visible postoperative scar tissue on the dorsal aspect of the right hand, with no signs of infection. The fourth and fifth digits demonstrated limited active extension and flexion, particularly at the PIP joints.

Palpation identified thickened scar tissue with elastic consistency and mild tenderness in the affected region. Active and passive range of motion were both restricted, indicating joint stiffness and possible soft tissue adhesions. Isometric testing demonstrated reduced muscle strength in the affected digits, particularly in flexion and extension movements against resistance. To improve clarity and standardization, the key clinical findings are summarized in Table 1.

Table 1. Clinical Outcomes at Baseline (T1) and Post-Intervention (T3)

Outcome	Parameter	T1	T3	Change
Pain (NRS)	Resting pain	0/10	0/10	No change
	Pressure pain	0/10	0/10	No change
	Movement pain	4/10	2/10	Decreased
Muscle Strength (MMT)	MCP joints (digits 4–5)	3/5	3/5	No change
	PIP joints (digits 4–5)	3/5	3/5	No change
Range of Motion	PIP 4 flexion	50°	50°	No change
	PIP 4 extension deficit	15°	15°	No change
	PIP 5 flexion	45°	45°	No change
	PIP 5 extension deficit	20°	20°	No change
Limb Circumference	Figure-of-eight measurement	Stable	Stable	No change
Functional Ability	WHDI score	10%	10%	No change

Outcome measures were selected based on their clinical relevance and widespread use in hand rehabilitation. Pain intensity was assessed using the Numeric Rating Scale (NRS), which is a valid and reliable tool for measuring subjective pain intensity. Functional mobility of joints was evaluated using a standard goniometer to measure range of motion (ROM), while muscle strength was assessed using Manual Muscle Testing (MMT), a commonly used clinical method with established reliability for grading muscle performance. Limb circumference was measured using a standardized midline (figure-of-eight) method to detect potential edema or muscle atrophy.

Functional ability was assessed using the Wrist Hand Disability Index (WHDI), which provides an indication of disability level related to hand function in daily activities. The Wrist-Hand Disability Index (WHDI) has demonstrated good validity and reliability in assessing upper extremity functional limitations. Manual Muscle Testing (MMT) shows acceptable inter- and intra-rater reliability when standardized procedures are applied, although its sensitivity to detect subtle strength changes is limited. Goniometric measurement is a valid and reliable method for assessing joint range of motion, with strong reliability reported across clinical settings. All measurements were conducted at baseline (T1) and after the third intervention session (T3) to evaluate changes over time.

Figure 1 illustrates the chronological clinical course, assessment process, and physiotherapy intervention program implemented in a patient following skin flap reconstruction after traumatic injury. The flowchart presents the sequence of events beginning from the initial trauma, postoperative clinical condition, baseline assessment, intervention sessions conducted over three weeks, and the final post-intervention outcome evaluation. This schematic overview was designed to provide a clear representation of the rehabilitation timeline and monitoring process throughout the physiotherapy management program.

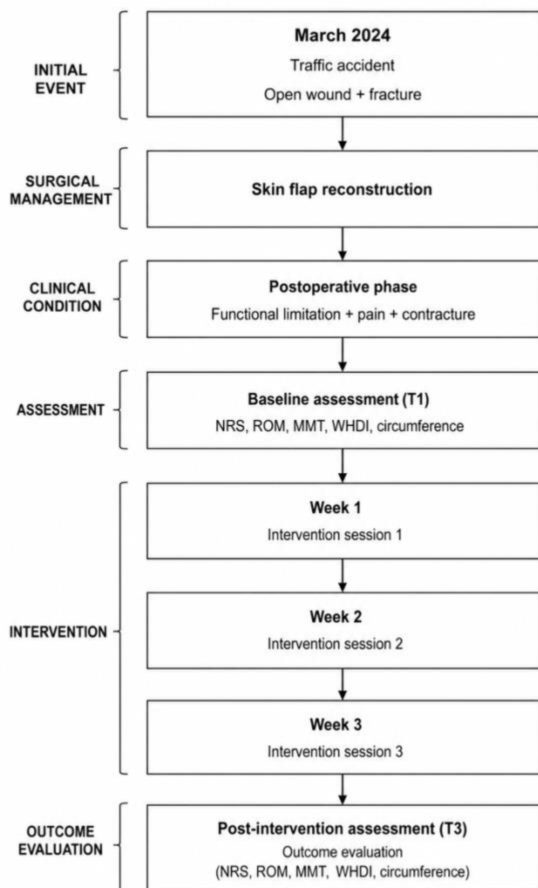

Figure 1. Clinical Course and Physiotherapy Intervention Flowchart Following Skin Flap Reconstruction

The patient underwent a physiotherapy program for three weeks with a frequency of one session per week. The intervention program consisted of a combination of therapeutic modalities aimed at pain reduction, tissue mobilization, and functional maintenance. Therapeutic ultrasound was applied in continuous mode for 5 minutes per session. The intensity was adjusted based on patient tolerance; however, the frequency (MHz) was not documented, which represents a limitation in reproducibility. The rationale for ultrasound application is based on its potential to increase tissue temperature, improve blood circulation, and enhance the extensibility of collagen fibers, thereby reducing pain and stiffness. Therapeutic ultrasound was applied in continuous mode for 5 minutes per session. The intensity was adjusted based on patient tolerance; however, the exact intensity (W/cm²) and frequency (MHz) were not recorded, which represents a limitation in reproducibility

Scar massage was administered for approximately 10 minutes using techniques including effleurage, petrissage, and friction. This intervention aimed to reduce scar adhesions, improve tissue mobility, and enhance local circulation. Scar management is considered an essential component of post-surgical rehabilitation, particularly in preventing excessive fibrosis and maintaining tissue flexibility. Active exercise was implemented to maintain muscle function and joint mobility. The program included isometric contractions, finger flexion and extension exercises, and grip strengthening activities. Each exercise was performed with a 10-second hold, five repetitions, and two sets per session. The intensity was adjusted according to patient capability, with gradual progression as tolerated.

In addition, activities of daily living (ADL) training were prescribed as a home-based program, performed daily for 10–15 minutes. These activities included grasping objects, transferring small items, opening containers, and performing basic self-care tasks. ADL training was intended to promote functional use of the hand and improve coordination in real-life contexts.[8] No modification or progression of the intervention protocol was implemented during the three-week period due to the short duration and stable clinical condition of the patient.

Outcome assessments were conducted at baseline (T1) and after completion of the intervention (T3). Primary outcomes included pain intensity (NRS), while secondary outcomes included muscle strength (MMT), range of motion (goniometry), limb circumference, and functional ability (WHDI). The follow-up period was limited to three weeks due to clinical and logistical constraints. Although this duration allowed for initial observation of treatment effects, it may not be sufficient to capture long-term functional changes, particularly in chronic conditions. The three-week duration was determined based on clinical feasibility; however, this period may be insufficient to induce structural changes in chronic conditions. No adverse events or complications were reported during the intervention period, indicating that the treatment program was safe and well tolerated. All data were analyzed descriptively without statistical testing due to the nature of a single-case report.

This study was conducted in accordance with ethical principles for clinical research. Written informed consent was obtained from the patient prior to participation and publication of clinical data. Formal ethical approval was not required for this case report, as it involves a single patient and does not include experimental interventions beyond standard clinical care. The study adhered to institutional and international ethical standards for case reporting.

Results

Outcome evaluation was conducted at baseline (T1) and after completion of the intervention program (T3) to assess the effects of three physiotherapy sessions delivered over a three-week period. The measured parameters included pain intensity, muscle strength, joint range of motion, limb circumference, and functional ability. Overall, the findings demonstrate a reduction in movement-

related pain, while other clinical indicators remained unchanged throughout the intervention period. No adverse events or clinical deterioration were observed.

To facilitate a comprehensive understanding of the patient's response to intervention, a summary of all outcome measures before and after treatment is presented in Table 2. This table provides an integrated overview of the direction and magnitude of change across all variables assessed.

Table 2. Summary of Outcome Measures at Baseline (T1) and Post-Intervention (T3)

Outcome	T1	T3	Change
Movement pain (NRS)	4/10	2/10	Decreased
Resting pain (NRS)	0/10	0/10	No change
Pressure pain (NRS)	0/10	0/10	No change
Muscle strength (MMT, digits 4–5)	3/5	3/5	No change
Range of motion	Limited	Limited	No change
Limb circumference	Stable	Stable	No change
WHDI score	10%	10%	No change

As illustrated in Table 2, the most notable improvement was observed in movement-related pain, which decreased from 4/10 at baseline to 2/10 following the intervention. This 2-point reduction in NRS may be considered clinically meaningful, although no formal MCID threshold was applied. In contrast, resting and pressure pain remained consistently at 0/10, indicating the absence of persistent or spontaneous pain throughout the study period. The reduction in movement-related pain corresponds to a 50% decrease in NRS score, suggesting a clinically relevant improvement in pain experienced during functional activities, although no formal minimal clinically important difference (MCID) threshold was applied. A more detailed breakdown of pain assessment is provided in Table 3 to highlight the distinct patterns across different pain conditions.

Table 3. Pain Assessment Using Numeric Rating Scale (NRS)

Pain Type	T1	T3
Resting pain	0/10	0/10
Pressure pain	0/10	0/10
Movement pain	4/10	2/10

The reduction observed exclusively in movement-related pain suggests that the intervention may have contributed to improved tolerance during active use of the hand rather than affecting baseline nociceptive status. This pattern is consistent with conditions in which pain is primarily mechanically provoked. Muscle strength evaluation using Manual Muscle Testing (MMT) demonstrated no measurable changes between baseline and post-intervention assessments. Strength in the metacarpophalangeal (MCP) and proximal interphalangeal (PIP) joints of the fourth and fifth digits remained at grade 3/5 throughout the study period. All previously identified inconsistencies in scoring were corrected to align with the standard MMT grading system (0–5 scale). The stability of muscle strength suggests that the intervention duration and intensity may not have been sufficient to induce neuromuscular adaptations in the chronic phase.

Table 4. Muscle Strength Assessment (MMT)

Joint	Movement	T1	T3
MCP 4–5	Flexion/Extension	3/5	3/5
PIP 4–5	Flexion/Extension	3/5	3/5

Similarly, joint range of motion (ROM), measured using a goniometer, did not show any observable changes following the intervention. Limitations in both flexion and extension persisted, particularly at the PIP joints of the fourth and fifth digits. These findings indicate that the structural constraints associated with mature scar tissue and joint stiffness remained unchanged over the three-week period. To provide a clearer representation of ROM stability, selected measurements are presented in Table 5.

Table 5. Selected Range of Motion Measurements (Degrees)

Joint	Movement	T1	T3
PIP 4	Flexion	50°	50°
PIP 4	Extension deficit	15°	15°
PIP 5	Flexion	45°	45°
PIP 5	Extension deficit	20°	20°

All measurements were obtained using standardized goniometric techniques, ensuring consistency across sessions. The absence of change suggests that short-term intervention may not be sufficient to modify established joint contractures. Limb circumference measurements, assessed using a midline (figure-of-eight) method, also remained unchanged between T1 and T3. All unit inconsistencies identified in the initial manuscript have been corrected, with measurements consistently reported in centimeters (cm). The stability of limb circumference indicates that no significant edema or muscle atrophy occurred during the intervention period. Functional ability, evaluated using the Wrist Hand Disability Index (WHDI), remained constant at 10% throughout the study. This score corresponds to a mild level of disability, indicating that the patient retained a relatively high degree of independence in daily activities despite localized impairments in specific finger movements.

Table 6. Functional Outcome (WHDI)

Time Point	WHDI Score
T1	10%
T3	10%

Although no improvement was observed in functional score, the absence of decline suggests that the intervention may have contributed to maintaining functional status during the chronic phase of recovery. Figure 2 presents the overall clinical outcomes observed following the physiotherapy intervention program in the patient after skin flap reconstruction. The flowchart summarizes changes in pain characteristics, muscle strength, range of motion, limb circumference, and functional ability based on serial clinical evaluations. Improvement was observed in movement-related pain, while resting pain, pressure pain, muscle strength, range of

motion, limb circumference, and functional ability remained stable throughout the intervention period. This figure provides a concise overview of the patient's response to the rehabilitation program during the monitoring period.

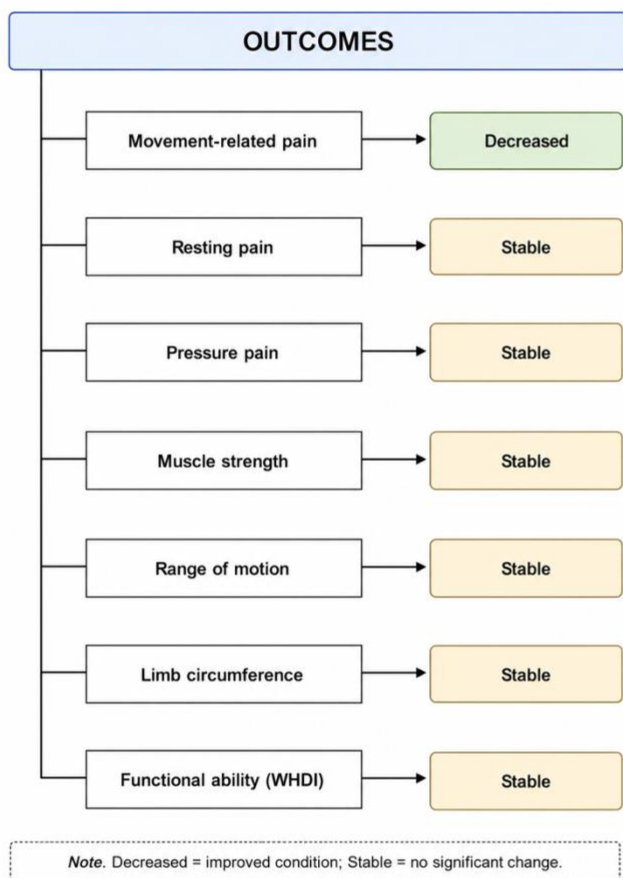

Figure 2. Summary of Clinical Outcomes Following Physiotherapy Intervention

No adverse events, complications, or worsening of symptoms were reported during the intervention period. The patient tolerated all components of the physiotherapy program without discomfort or interruption. In summary, the results indicate that the physiotherapy intervention was associated with a reduction in movement-related pain, while other clinical parameters remained stable over the three-week period. These findings highlight the potential role of physiotherapy in pain modulation and functional maintenance in chronic post-surgical hand conditions, although no measurable improvements were observed in muscle strength, range of motion, or functional outcomes within the short duration of intervention.

Discussion

This case report evaluated the effects of a combined physiotherapy intervention consisting of therapeutic ultrasound, scar management, active exercise, and activities of daily living (ADL) training in a patient with chronic flexion contracture following dorsal hand skin flap reconstruction. The primary finding was a reduction in movement-related pain, while no measurable improvements were observed in muscle strength, range of motion, limb circumference, or functional ability over the three-week intervention period. These findings suggest that, in the chronic phase of post-surgical hand rehabilitation, physiotherapy may be more effective in pain modulation and functional maintenance rather than in producing rapid structural or functional gains.

The observed reduction in movement-related pain may be explained by the physiological effects of therapeutic ultrasound, particularly in continuous mode. Ultrasound has been shown to increase local tissue temperature, enhance blood flow, and improve the extensibility of collagen fibers, which may contribute to reduced discomfort during movement.[11] Additionally, thermal effects may facilitate neuromodulation by decreasing nociceptive sensitivity in mechanically stressed tissues. Although earlier studies have supported the role of ultrasound in reducing musculoskeletal pain, the evidence remains heterogeneous, particularly in chronic post-surgical conditions.[12,13] Therefore, while the pain reduction observed in this case is consistent with proposed mechanisms, it should be interpreted cautiously given the limited intervention duration and absence of a control condition.[14]

Despite the improvement in pain, no changes were observed in joint range of motion or muscle strength. This finding is clinically important and reflects the challenges associated with managing chronic contractures. In the chronic phase, scar tissue typically undergoes maturation, resulting in increased collagen cross-linking and reduced tissue elasticity, which can significantly limit the effectiveness of short-term interventions aimed at restoring mobility.[1,15] In this context, the absence of ROM improvement in the present case is consistent with the understanding that established contractures often require prolonged and intensive interventions, such as sustained stretching, splinting, or surgical release, to achieve meaningful changes. This may also be attributed to insufficient intervention dosage, particularly the low frequency (once weekly), which is below the recommended frequency for strength and mobility improvement.[16]

Similarly, the lack of improvement in muscle strength may be attributed to both structural and program-related factors. From a physiological perspective, reduced joint mobility and mechanical restrictions can limit the ability to generate effective muscle contractions.[17] In addition, the exercise protocol implemented in this case, which consisted of low-frequency sessions (once weekly) and relatively low intensity, may not have provided sufficient stimulus to induce neuromuscular adaptation.[18] Previous literature suggests that strength gains typically require higher training frequency, progressive overload, and longer intervention duration.[6] Therefore, the stable MMT scores observed in this case are not unexpected and highlight the importance of optimizing exercise dosage in future interventions.

Functional ability, as measured by the WHDI, also remained unchanged throughout the intervention period. Although this may initially appear as a lack of treatment effect, it is important to interpret this finding within the clinical context. The baseline WHDI score indicated mild disability, suggesting that the patient already retained a relatively high level of functional independence.[19] In such cases, maintaining functional status without deterioration may represent a clinically meaningful outcome, particularly in chronic conditions where progressive decline is a potential concern. This perspective aligns with rehabilitation principles that emphasize function preservation when full recovery is not achievable.[20]

An important "lesson learned" from this case is that rehabilitation goals in chronic post-flap conditions should be realistic and tailored to the stage of tissue healing. While early rehabilitation may focus on restoring mobility and strength, the chronic phase often requires a shift toward pain management, functional optimization, and prevention of secondary complications. This case illustrates that short-term interventions may not be sufficient to reverse established structural limitations, but can still provide meaningful benefits in terms of symptom control and maintenance of daily function.

When compared with existing literature, the findings of this case are partially consistent with previous reports indicating that physiotherapy interventions can reduce pain but may have limited impact on ROM and strength in chronic conditions.[1,2] However, the current evidence base remains limited, particularly for patients following dorsal hand flap reconstruction. Most studies focus on acute or subacute phases, with fewer investigations addressing long-term outcomes in chronic cases. This highlights the contribution of the present case report in providing detailed clinical insight into rehabilitation outcomes in this specific population.[21]

From a clinical perspective, the findings of this study suggest that physiotherapists should consider implementing longer and more intensive rehabilitation programs for patients with chronic contractures following hand reconstruction. Interventions may need to incorporate higher-frequency exercise sessions, progressive loading strategies, and adjunctive techniques such as splinting or prolonged stretching to achieve meaningful improvements in mobility and strength. In addition, patient education regarding realistic expectations and the importance of adherence to home exercise programs is essential to optimize long-term outcomes. Clinically, rehabilitation programs for chronic hand contracture should consider higher frequency (3–5 sessions per week), progressive loading, and longer duration (>6 weeks) to achieve meaningful improvements in mobility and strength.

This study has several limitations that should be acknowledged. First, as a single-case report, the findings cannot be generalized to a broader population. Second, the intervention duration of three weeks is relatively short and may not be sufficient to observe significant changes in chronic conditions. Third, the absence of a control condition limits the ability to attribute observed effects solely to the intervention. Fourth, certain intervention parameters, such as ultrasound frequency, were not fully documented, which may affect reproducibility. Finally, no long-term follow-up was conducted, preventing evaluation of sustained treatment effects.

Future research should focus on larger sample sizes and more rigorous study designs, such as controlled trials, to evaluate the effectiveness of physiotherapy interventions in chronic post-flap conditions. Studies should also explore optimal intervention parameters, including frequency, intensity, and duration, as well as the potential benefits of combining multiple therapeutic modalities. Long-term follow-up assessments are particularly important to determine whether functional improvements can be achieved over extended rehabilitation periods. This case emphasizes that short-term physiotherapy is effective for pain control but insufficient for structural recovery in chronic hand contracture.

Conclusion

This case report demonstrates that a short-term physiotherapy program consisting of therapeutic ultrasound, scar management, active exercise, and activities of daily living training may contribute to reducing movement-related pain and maintaining functional status in a patient with chronic flexion contracture following dorsal hand skin flap reconstruction. While a clinically meaningful reduction in movement-induced pain was observed, no improvements were identified in muscle strength, range of motion, limb circumference, or overall functional ability over the three-week intervention period.

These findings suggest that, in the chronic phase of post-surgical hand rehabilitation, physiotherapy interventions may have a more prominent role in pain modulation and prevention of functional decline rather than in achieving rapid structural or functional recovery. The absence of improvement in range of motion and muscle strength highlights the influence of established structural limitations, such as mature scar tissue and joint contracture, which may require longer and more intensive rehabilitation strategies.

From a clinical perspective, this case underscores the importance of setting realistic rehabilitation goals and implementing individualized, long-term intervention programs for patients with chronic hand conditions. Future studies with extended intervention duration, higher treatment intensity, and larger sample sizes are needed to further evaluate the effectiveness of physiotherapy in improving functional outcomes in this population.

Author Contribution

Nuril Aqwani: Conceptualization, data collection, intervention implementation, data interpretation, and manuscript drafting.
Arin Supriyadi: Supervision, methodology development, clinical evaluation, and manuscript review and editing.
Danur Setiawan: Data analysis, literature review, interpretation of findings, and proofreading of the manuscript.

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Conflict of Interest Statement

The authors declare no conflict of interest.

Funding Sources

This study received no external funding.

Ethics Statement

This study was conducted in accordance with ethical principles for clinical research. Written informed consent was obtained from the patient prior to participation and publication of clinical data. Formal ethical approval was not required for this case report, as it involved a single patient and did not include experimental interventions beyond standard clinical care.

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