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Case Study

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Integrated physiotherapy through electrical stimulation and biofeedback for complex middle–lower trunk brachial plexus injury- A case report

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Abstract

This case study presents the rehabilitation management and follow-up recovery of a 63-year-old female patient who sustained a fall resulting in neurological deficits. The injury led to wrist drop and weakness of the interossei muscles, contributing to the development of claw hand deformity. The clinical presentation suggested involvement of the middle and lower brachial plexus, significantly impairing her hand function and quality of life. Electrical stimulation, biofeedback training, and a structured strengthening programme were implemented to reinforce the weakened hand and wrist musculature to ensure overall dexterity. This case study highlights the efficacy of a personalised rehabilitation approach in managing rare middle and lower brachial plexus injuries.

Keywords: Brachial plexus injury, physiotherapy, biofeedback training, electrical stimulation, claw hand

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INTRODUCTION

The anatomical structure of the brachial plexus is formed by the roots of the cervical and thoracic spinal cord [1]. It comprises three trunks: the upper trunk is formed by the union of C5 and C6 ramus, the middle trunk is formed by the C7 ramus and the lower trunk is formed by the C8 and T1 rami [2]. Brachial Plexus Injury (BPI) is rare in the general population but most commonly seen in road traffic accidents. With a history of high velocity impact, patients' injuries can result in axonotmeses or neurotmesis [3]. Most brachial plexus pathologies in adults result from closed trauma, with nerve damage primarily caused by traction and compression [4]. Approximately 95% of cases are caused by traction injuries, resulting from stretching and compression of the nerves due to trauma, improper upper-limb positioning during surgery, or direct injury [5]. Studies suggest that traumatic BPI occur at the rate of 1.2 to 2.8 per 100,000 individuals per year, with the lower trunk less frequently involved than the upper trunk. Upper plexus injuries comprised 26.8% of cases. Lower plexus injuries represented 22% of cases [5]. Among the different types of BPI, middle and lower trunk involvement (C7, C8, and T1), each presents unique functional impairments, primarily affecting the elbow, wrist, and hand. While upper trunk injuries are more commonly reported, cases involving simultaneous middle and lower trunk damage are less frequent and present significant challenges for diagnosis and rehabilitation. In addition, isolated or combined injuries to the middle and lower trunk are significantly less common. This case report highlights the importance of recognising and diagnosing middle and lower brachial plexus injuries, as the clinical presentations may be less obvious and may require tailored treatment approaches. The scarcity of data on these injuries underscores the need for further research to better understand their prevalence, mechanisms, and management, particularly in the context of India, where trauma-related injuries are prevalent.

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CASE

This case study was conducted at the Advanced Neurorehabilitation Unit of the Faculty of Physiotherapy,

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Dr MGR Educational and Research Institute, Velappanchavadi. The study was carried out following approval from the Institutional Review Board of the faculty of physiotherapy, DRMGRERI (Reference No. ANRU12/PHYSIO/IRB/2024–2025), and was conducted in accordance with the principles outlined in the revised Helsinki Declaration of 2008.

A 63-year-old woman presented to the advanced neurorehabilitation unit with complaints of difficulty holding and picking up objects. She reported having fallen down a flight of stairs two days before presentation. Additionally, she has a six-month history of hypertension and was on regular medication. She was referred to the physiotherapy department for further management. On observation, the patient's left shoulder appeared adducted and depressed, with the wrist and fingers in a flexed posture, indicating a muscle imbalance. Examination of the deep tendon reflexes revealed diminished responses (grade +) in the wrist flexors, wrist extensors, and finger flexors, while elbow reflexes remained normal. Muscle power assessment using the Medical Research Council (MRC) Muscle Strength Scale revealed a grade of 3+ at the elbow, 2- at the wrist, and 1+ at the fingers. The 4th and 5th digits showed a power of 2+, while the 1st, 2nd, and 3rd digits had a power of 1+ (Table 1). Sensory assessment indicated altered sensation over the C7, C8 and T1 dermatomes. Further examination revealed a positive card test. Overall hand function was evaluated using the Sollerman Hand Function Scale, with a score of 56 out of 80, indicating moderate functional limitation. Electrophysiological analysis was conducted using the strength-duration (SD) curve. The analysis revealed a chronaxie value of 100ms. The SD curve shifted towards the right, a characteristic finding indicative of de-innervation, thereby further confirming nerve involvement in the middle and lower trunk of the brachial plexus. These findings indicate neuromuscular dysfunction in the left upper limb, characterised by weakness, diminished tone, sensory impairment and moderate hand function limitation, which needed targeted rehabilitation and further evaluation.

INTERVENTION

In this case, physiotherapy played a crucial role in enhancing muscle strength, particularly targeting the interossei and wrist extensor muscles. Electrical stimulation was administered over the Extensor carpi radialis longus, Extensor carpi radialis brevis, Extensor carpi ulnaris, Extensor digitorum, Extensor policis longus, Extensor Digiti minimi of radial nerve and interossei, Flexor carpi ulnaris, Flexor digitorum profundus of ulnar nerve motor points using galvanic current with a duration of 100ms, based on the principle of chronaxie, to activate and strengthen the affected muscles. Every week the innervation was evaluated using SD curve and the duration of the current was changed according to the chronaxie. Additionally, Electromyographic biofeedback training was employed to improve voluntary muscle control, along with

Figure 1. Biofeedback training using Medicad EMG-Biofeedback

Table 1. Group Muscles grade of the affected muscles before and after the intervention, according to the MRC Grading.

Group of muscles	Muscle grade according to daniel worthingham scale (before intervention)	Muscle grade according To daniel worthingham scale (after 6 weeks of intervention)
Elbow flexors	3+	4+
Wrist extensors	2-	4+
Finger extensors	2+	4+
Finger flexors	1+	4-

4+ Full ROM against gravity, moderate to strong resistance
4- Full ROM against gravity, slight to moderate resistance
3+ Full ROM against gravity with minimal resistance
2- Partial range of motion in gravity eliminated position
2+ Full ROM in gravity-eliminated position and slight resistance tolerated
1+ Flicker or slight contraction of the muscle with minimal visible movement

Table 2. Protocol for electrical stimulation with duration and biofeedback training

No. of Weeks	Duration of galvanic current(ms)	Exercises given	Biofeedback training
WEEK 1	100ms	Rest, splinting (cockup splint) re-education board, active assisted exercises	-
WEEK 2	100ms	Re-education board, isometric strengthening exercise for wrist extensors and lumbricals	Observe EMG signals during voluntary attempts, focus on relaxation of overactive flexors
WEEK 3	30ms	Pegboard exercises, resisted exercise using putty, task specific training (grasp and release activities)	Attempt controlled movements while watching feedback, avoid compensatory strategies
WEEK 4	30ms	Dexterity training (pegboard, coin stacking) proprioceptive training like ball squeezing, sensory re-education	Focus on smooth, sustained contractions without excessive co-contraction
WEEK 5	10ms	Weight bearing activity, ADL training, grip strengthening exercises	Reduce excessive grip force, improve controlled release of objects
WEEK 6	Faradic current	ADL training, neuromuscular training for adaptive strategies	Use EMG biofeedback intermittently for self-correction, integrate into ADLs

a structured regimen of progressive resisted exercise, including theraband-based wrist extension, finger abduction/adduction against elastic resistance, putty squeezing and pinching, and light dumbbell wrist extension. Functional exercises were incorporated to promote wrist and finger extension, abduction, and adduction, including pegboard tasks, coin manipulation, reach-to-grasp activities, and bimanual tasks such as buttoning and opening jars, thereby improving coordination, dexterity, and hand function. Stretching and proprioceptive training were also included to enhance muscle flexibility and neuromuscular control, ultimately promoting better hand mobility and overall functional recovery.

RESULTS

Pre-intervention assessments revealed a chronaxie value of 100 milliseconds, indicating severely reduced nerve excitability, a common finding in brachial plexus injury. The initial solleman score was 56/100, consistent with moderate impairment in hand function. After six weeks of structured intervention, the neuromuscular response improved markedly: the chronaxie value decreased to 0.1 milliseconds, signifying enhanced nerve excitability and improved motor unit recruitment. The Solleman score decreased to 38/100, reflecting improved muscle power and performance in daily tasks, as lower scores indicate better outcomes. These improvements were sustained at the 24-week follow-up, indicating a lasting therapeutic effect in BPI rehabilitation.

DISCUSSION

The present study demonstrated a notable improvement in isometric wrist extensor strength following electrical stimulation (ES), with enhanced wrist movement by the end of the treatment phase. This improvement was sustained even after 24 weeks post-intervention, indicating a lasting therapeutic effect. Clinical studies emphasise that electrical stimulation (ES) is an effective modality in brachial plexus injury rehabilitation. ES was identified as a key adjunct to surgical repair in rehabilitation protocols, supporting sustained neuromuscular excitability and functional recovery [6]. Prospective neurophysiological data demonstrated that ES improves excitability and supports structured rehabilitation procedures in patients with brachial plexus injuries [7]. Functional improvement was reported in patients with brachial plexus injury when ES was combined with conventional therapy, reinforcing its role in clinical practice [8]. Collectively, these findings validate ES as a scientifically grounded intervention that contributes to sustained neuromuscular excitability and functional restoration of the upper limb. The effects of ES may also involve cellular mechanisms, such as modulation of Schwann cell activity via increased calcium influx and enhanced responsiveness to neurotrophic factors [7].

Additionally, ES appears to influence immune responses by promoting an anti-inflammatory macrophage phenotype, potentially accelerating the repair process during nerve recovery [8]. Furthermore, adjunct therapies such as electromyographic biofeedback (EMG-BF) have demonstrated superior outcomes in upper extremity rehabilitation post-stroke, especially in managing spasticity of wrist flexors, compared with conventional physical therapy [9]. A recent systematic review and meta-analysis confirmed that EMG BF significantly improves limb function after stroke, strengthening its evidence base in neurorehabilitation [10]. Clinical trials have further demonstrated that EMG BF is superior to conventional therapy in reducing wrist flexor spasticity, reinforcing its therapeutic value for functional recovery. Neurofeedback and other forms of biofeedback have been shown to modulate brain activity by translating electrical signals into perceptible feedback, enabling individuals to consciously regulate neural responses. These interventions help patients become aware of subtle muscular contractions and engage in targeted neuromuscular retraining. Such feedback-driven therapies may enhance cortical reorganisation and muscle reinnervation, ultimately contributing to the recovery of motor function [11].

The neuromuscular and functional outcomes in this study were assessed using the Strength-Duration (SD) curve and Sollerman's Hand Function Scale. The pre-intervention chronaxie value of 100 milliseconds indicated severely reduced nerve excitability, a common finding in peripheral nerve injuries. Functionally, the initial Sollerman score was 56/100, suggesting moderate impairment. After six weeks of structured intervention (Table 2), there was a marked improvement in neuromuscular response, with the chronaxie value decreasing to 0.1 milliseconds, signifying enhanced nerve excitability and improved motor unit recruitment. Notably, the Sollerman score also decreased to 38/100 post-intervention, indicating a significant positive shift in hand function. This reduction reflects improved muscle power and performance in functional tasks, as lower scores on the scale denote better outcomes in this context.

The simultaneous improvement in both electrophysiological and functional parameters suggests that the intervention was effective in promoting neural recovery and restoring upper limb functionality.

Conclusion

This case study highlights the effectiveness of a multimodal rehabilitation approach in managing wrist drop and claw-hand deformity resulting from a middle-lower trunk brachial plexus injury. Electrical stimulation, biofeedback, and strengthening exercises were associated with measurable improvement in neuromuscular function and hand performance. Specifically, the chronaxie value improved from 100ms pre-intervention to 0.1ms post-intervention, indicating enhanced nerve excitability and motor unit recruitment. Muscle strength across the elbow, wrist, and fingers showed notable gains, while functional capacity improved as reflected in the Sollerman Hand Function Test scores. These outcomes suggest that the structured six-week intervention protocol facilitated neuromuscular recovery and improved functional independence.

The physiotherapist played a key role in preventing deformities and optimising motor function. Their expertise in task-specific training and neuromuscular re-education was crucial for patient progress. Physiotherapists should contribute to research to refine treatment strategies and explore advanced rehabilitation techniques. Future studies should focus on long-term outcomes and enhancing neuroplasticity for improved recovery.

DECLARATIONS

Ethical consideration

Ethical approval was obtained from the Institutional Review Board of the Faculty of Physiotherapy, DRMGRERI (Reference No. ANRU12/PHYSIO/IRB/2024–2025).

Consent to publish

All authors agreed on the content of the final paper.

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Competing Interest

The authors declare no conflict of interest

Author contribution

TG and SK conceptualised and designed the study. EK and SK conducted the treatment session. TG, SK, SN, and EK collaborated to write the paper, summarising the findings and contributions.

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Availability of data

Data is available upon request to the corresponding author.

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