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Research article

High radial nerve injury in adolescents. Case report - evalution of functional recovery and the role of physiotherapy in the chronic stage

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Abstract: Peripheral radial nerve injuries in pediatric patients present complex therapeutic challenges. This case report describes the management of an adolescent with a high radial nerve injury and evaluates the functional recovery and the role of physiotherapy in the chronic stage. The patient underwent a personalised therapeutic protocol, which included passive and active mobilisation, progressive muscle strengthening, occupational therapy, and techniques to address sensory deficits. Functional assessment was performed using specific scales, showing significant progress from the initial to the final evaluation. The favourable outcome underscores the critical importance of an adapted and continuous physiotherapy program during the chronic stage. This case report concludes that a tailored physical therapy program is a fundamental pillar in functional recovery, preventing complications (such as muscle atrophy and joint stiffness), and improving the overall quality of life, leveraging the heightened neural plasticity of adolescent patients for a more favourable prognosis.

Keywords: radial nerve injury, pediatric rehabilitation, physical therapy, functional recovery, chronic stage

1. Introduction

This article highlights current data on the management of radial nerve injuries in adolescents, a population with exceptional recovery potential but also specific challenges. According to several studies, the incidence of traumatic radial nerve injuries among young people is estimated to be between 5% and 15% in cases of humeral shaft fractures, with the main mechanism related to sports or traffic accidents [1,2].
The prospects for recovery from peripheral nerve injuries vary depending on the type and severity of the lesion, with the most favourable prognoses associated with neurapraxia. Some studies indicate total or partial functional recovery in 85-90% of cases with closed injuries (neurapraxia), especially with adequate conservative management [3,4]. Interventions range from conservative waiting, accompanied by early and adapted physical therapy, to surgical procedures (exploration, neurolysis, nerve suture) for severe or open injuries. The average recovery time for a significant functional improvement is approximately 3-6 months for milder injuries, but it can extend to 12 months or more for maximum recovery in cases of axonotmesis or neurotmesis [5,6], underscoring the importance of patience and continuous therapy.

The purpose of this case report is to illustrate the practical application of these principles by presenting the management of an adolescent with a high radial nerve injury, highlighting the therapeutic challenges and the functional outcome achieved through an adapted and prolonged physiotherapy protocol.

2. Materials and Methods

2.1. Case presentation

Patient U.S., a 16-year-old male, sustained a complete traumatic transection of the right radial nerve secondary to an accident, necessitating surgical intervention via epineural neurorrhaphy. The initial clinical presentation was characterized by significant pain (7/10 on the VAS), a classic wrist drop deformity with an inability to extend the wrist and fingers, loss of prehensile function, and pronounced dominance of the flexor muscle groups.

At the 9-month postoperative follow-up, the clinical course was favorable, evidenced by complete resolution of pain and full restoration of elbow range of motion. While functional recovery was observed—allowing the patient to resume basic activities of daily living such as writing and eating—significant deficits persisted. These residual impairments included incomplete active extension of the fingers and wrist (muscle strength graded at 3/5 on the MRC scale), rapid muscle fatigability, a weakened grip strength leading to frequent object dropping, and mild muscular atrophy. Additionally, the patient exhibited a compensatory posture of slight wrist flexion (10-15°) at rest and demonstrated subconscious avoidance of strenuous activities with the affected limb.

2.2. Recovery management and the role of physiotherapy

Managing a long-term radial nerve injury in pediatric patients requires a team effort and a clear plan based on proven methods [7,8]. This text describes the case of a 16-year-old boy, U.S., with a complete radial nerve injury in his right arm. He was examined nine months after his surgery [9,10]. The goal was to measure his recovery and plan his therapy. Nerve injuries in pediatric patients are particularly challenging because of ongoing tissue and metabolic changes, particularly in muscular and nerve recovery [11,12].

The examination began with an evaluation of his muscle strength. The results showed a common pattern: muscles closer to his shoulder were stronger, while those farther away, like his finger flexors, were weaker. This happens because nerve fibres have to regrow over a long distance to reach the finger muscles, a slow process [6,11,13,14]. Measurements of his joint movement showed he couldn't straighten his wrist or turn his palm down as much as he should. This was caused by both weak muscles and stiff joints, a known problem after prolonged arm immobilisation [2,15,16].

Next, we tested how well he could use his hand. A "Drop Hand Test" showed he couldn't hold his wrist up on its own, which is a key sign of a radial nerve injury [17,18]. Another test, the "9-Hole Peg Test", took him 25 seconds, which is slower than normal, showing he had trouble with fine coordination [6,18]. Moreover, when asked about his daily activities using the ABILHAND-KIDS questionnaire, he reported no problems. This means he had found clever ways to adapt, even though we noticed he sometimes avoided using the weak arm for harder tasks [18,19]. He also reported no pain, which was excellent news for his therapy [4,5]. Finally, a physical exam found that the muscles on the back of his forearm were slightly smaller, and the wrist joint felt stiff, which confirms the effects of the nerve injury and the partial use of the muscles [2,18,20].

The check-up at nine months helped us understand his progress by linking what we saw to known medical facts [10]. The continued weakness of his finger muscles (grade 3/5) indicates that the nerves are only partially reconnected. At this stage, he can move his fingers against gravity but not against resistance, which matches what we know about slow nerve healing [1,14,20]. The limited movement in his wrist and forearm is due to both weak muscles and stiff tissues around the joint, telling us that therapy must continue to focus on improving flexibility [1,2,16].

His wrist was resting in a slightly bent position (10-15°). Keeping the wrist slightly flexed helps the weak finger muscles grip better, a common adaptation described in several studies [14,21,22]. The slight shrinking of the muscles is a direct result of their underuse after the nerve was injured [18,20]. Joint stiffness is also a known side effect of prolonged arm immobility [2,6,16]. The fact that his pain went from a 7/10 to 0/10 is a very positive sign, showing that the healing nerves are recovering well [4,5].

A significant conclusion from this case is the discrepancy between the test results and the patient's symptoms. While our tests clearly showed he was slower and less coordinated, he himself felt his hand worked perfectly for daily tasks. This shows he had learned effective tricks to manage [18,19]. For a therapist, this means treatment goals must balance improving actual performance with respecting the patient's own satisfaction and ability to live their life [18,23]. In summary, after nine months, he had made very good, but not yet complete, progress [12,24].

After surgery, the patient followed a 9-month recovery plan divided into three main phases, each with a distinct goal [25,26]. This step-by-step method ensures the therapy matches the stage of nerve healing, moving from protection to building strength and finally to retraining for daily life [4,27,28].

Phase 1 Early Protection (Months 1-3). The main goal at the start was to protect the healing nerve, a critical period for supporting the fragile regenerative environment [29,30]. The arm was kept still to allow the nerve repair to settle [7,27]. During this time, the therapist moved his joints for him (passive movement) and then helped him move them himself (assisted movement) to prevent them from getting stiff [2,16,27]. They also used different sensations, like touch, on his skin to "wake up" the brain's connection to the arm, which is very important early on [7,17,31]. The session frequency was 3-4 times per week, with each session lasting 45 minutes.

Phase 2 Building Strength (Months 4-6). Once the nerve was more stable, the focus shifted to strengthening, capitalising on the onset of axonal reinnervation [8,27]. He started doing resistance-band exercises to build his muscles. The activities became more practical and functional. This approach directly reflects the evidence supporting graded resistance training for restoring motor control and muscle strength once the nerve has had sufficient time to initiate regeneration [5,27,31]. The frequency of sessions increased to 4-5 times per week, lasting 50-60 minutes per session.

Phase 3 Advanced Functional Training (Months 7-9). The final phase focused on building muscle endurance and reintegrating the hand into all daily activities, aiming for the highest levels of functional recovery [4,12]. Therapy included tasks that used both hands together and practised specific everyday skills. This aligns with the goal of occupational therapy: to make the hand useful again in real-life situations [21,23]. The frequency was maintained at 5 sessions of 60 minutes per week.

In the last part of this phase, 9 months after surgery, he followed a focused 4-week program that included exercises such as active wrist movements, squeezing a resistance ball, and practising skills like writing and catching a ball [5]. Week 1 focused on mobilisation and neuromuscular activation. Exercises included active wrist extension (holding for 3 seconds, 15-20 repetitions) and forearm rotation (supination/pronation) using a stick (12-15 repetitions per set), following principles of graded exercise progression for nerve regeneration [20]. Week 2 concentrated on muscle strengthening. Exercises involved squeezing a resistance ball (15-20 repetitions) and passive stretching of the fingers (holding each finger for 5 seconds), employing resistance training techniques shown to enhance motor recovery [20,32]. Weeks 3 & 4 shifted to more functional activities. These included rapid writing practice and throwing/catching a tennis ball, with sessions lasting 15-20 minutes and tailored to the patient's ability [5,21], reflecting occupational therapy approaches to functional reintegration [33]. These aimed to restore age-specific skills, improving speed, accuracy, and hand-eye coordination. Progression during these weeks was dictated by performance on functional assessments, such as the time on the "9-Hole Peg Test" and the ABILHAND-Kids score, with tasks becoming progressively more complex and demanding (e.g., catching a smaller ball or writing under time constraints).

All exercises were adapted to the patient's capacity, following the fundamental rehabilitation principle of patient-specific exercise prescription [5]. The goal was to increase effort and achieve the set recovery targets gradually, so his hand could be successfully reintegrated into his normal activities, aligning with comprehensive nerve rehabilitation frameworks that emphasise functional restoration [2,12,25].

The 4-week intensive therapy phase was introduced to consolidate the functional gains achieved during the initial 9 months of recovery and to optimally stimulate neuroplasticity at a time when distal reinnervation had reached a clinically meaningful threshold. Current neurorehabilitation literature indicates that the period of highest cortical and spinal responsiveness following peripheral nerve repair occurs within the first 3–6 months post-injury, while synaptic consolidation, sensorimotor reintegration, and refinement of motor control strategies may continue for up to 12 months. Therefore, a focused and structured high-intensity intervention during the later stage of recovery can reduce the persistence of maladaptive compensatory patterns, enhance fine motor control, and accelerate the functional integration of reinnervated muscle groups.

3. Results

The initial assessment, conducted 9 months post-surgery, revealed the typical impairments associated with a radial nerve injury, including muscle weakness, limited range of motion, and the absence of major neurological signs. Following the completion of a personalised, 4-week physical therapy program tailored to the patient's specific needs, a significant improvement in his condition was noted. Clear progress was observed in muscle strength, joint mobility, and overall function. For a clearer overview of the outcomes recorded at the beginning and end of the therapy, these results are summarised in the tables and charts below.

Table 1. Evolution of Functional Tests and Pain Status

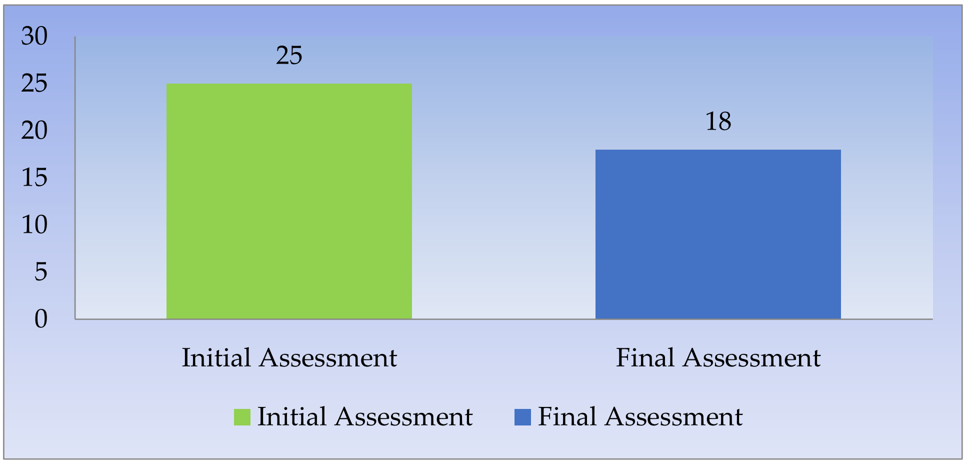
Test / Measure	Initial assessment	Final assessment	Interpretation
Drop Hand Test	Incomplete	Complete	Significant recovery. Elimination of the pathognomonic clinical sign for radial nerve injury indicates the restoration of neurological control over active wrist extension.
9-Hole Peg Test (seconds)	25 seconds	18 seconds	Remarkable improvement in fine coordination and execution speed. The time reduction reflects excellent recovery of dexterity and neuromotor integrity.
ABILHAND-KIDS Scale	Complete score	Complete score	Maintenance of a high functional level. The The patient remained independent in all activities of daily living, with no restrictions due to the affected limb.
VAS Scale (Pain)	0/10	0/10	Total absence of pain. The state of comfort was maintained throughout the entire therapeutic intervention.

Table 1 summarises the key functional and pain-related outcomes for our patient, U.Ș., comparing his initial and final assessments. The results demonstrate a highly successful recovery trajectory, which strongly correlates with established theoretical principles and findings from other clinical studies [25,34].

The resolution of the pathognomonic "Wrist Drop" sign, confirmed by the Drop Hand Test, marks a critical milestone. This indicates successful reinnervation of the wrist extensor muscles, allowing for active anti-gravity movement—a primary goal in radial nerve rehabilitation [17,35]. The sequential nature of this recovery, where proximal muscles regain function before distal ones, is a classic feature of axonal regeneration and is well-documented in the literature [6,11,14].

Furthermore, the remarkable 7-second improvement on the 9-Hole Peg Test signifies a transition from basic motor recovery to the restoration of fine dexterity and neuromotor integrity. This improvement reflects enhanced neural signalling, improved coordination, and cortical reintegration, outcomes achieved through task-specific training that promotes neural plasticity [4,31,36]. A pivotal finding was the consistent "Complete" score on the ABILHAND-KIDS questionnaire, which highlights the distinction between physical impairment and functional disability. It demonstrates the patient's successful use of compensatory strategies prior to therapy, a known adaptive phenomenon [18,19]. The restoration of physiological function through rehabilitation thus supplemented, rather than disrupted, this pre-existing adaptive capacity.

Chart 1 - Functional Tests (9-Hole Peg Test)



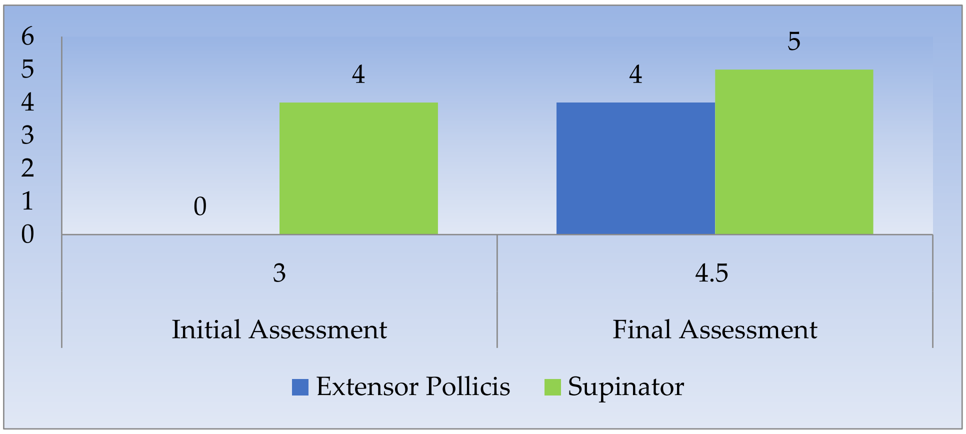
When we tested muscle strength using the Medical Research Council (MRC) Scale, the results showed clear, steady progress. The muscles supplied by the radial nerve became consistently stronger over time.

Table 2. Evolution of Muscle Strength (MRC Scale)

Muscle Group	Initial Assessment	Final Assessment	Interpretation
Finger Extensors	3/5	4+/5	Significant muscle strengthening. Transition from extension, possible only against gravity, to one performed against moderate resistance, with significant amelioration of the extensor lag.
Extensor Pollicis	3-4/5	4/5	Reduction of the extension deficit. Partial recovery of innervation led to improved functional strength and amplitude.
Supinator	4/5	5/5	Complete recovery of supination is essential for activities such as opening a lid or turning a key.

Table 2 outlines the recovery of muscle strength in key radial nerve-innervated muscle groups over the course of the rehabilitation program. The progress shown aligns with established theories of nerve regeneration and demonstrates a classic pattern of functional recovery [10,26].

Chart 2 - Muscle Strength (MRC Scale)



The recorded gains in muscle strength, measured by the MRC Scale, vividly illustrate the established proximal-to-distal gradient of nerve regeneration. The supinator muscle achieved a full recovery (5/5), a common finding as it is innervated most proximally, requiring the shortest axonal regrowth distance [22]. The extensor pollicis showed strong recovery (4/5), indicating progressive reinnervation crucial for key pinch and grasp.

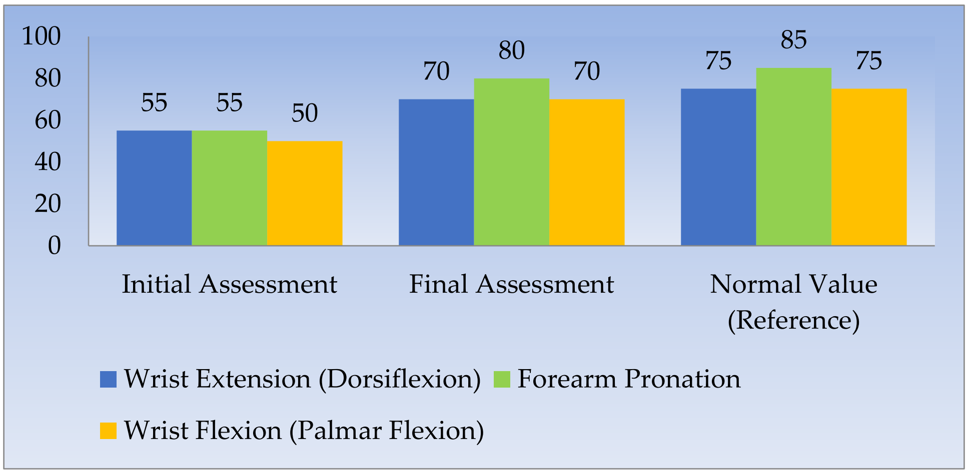
The finger extensors, being the most distal, showed significant but incomplete recovery (4+/5). This pattern is physiologically expected, as these muscles are the last to be reinnervated [6,14]. The progression from anti-gravity movement (3/5) to movement against resistance (4+/5) signifies successful axonal regeneration, remyelination, and muscle fibre hypertrophy resulting from targeted strengthening [5,10,31]. The reduction in extensor lag is a direct clinical correlate of this improved neuromuscular control.

Table 3. Evolution of Joint Mobility (Degrees)

Joint Movement	Initial Assessment	Final Assessment	Interpretation
Wrist Extension (Dorsiflexion)	55°	70°	Recovery of the normal range of motion. Regained extensor strength restored the full range of motion necessary for hand-opening activities.
Forearm Pronation	55°	80°	Dramatic improvement. Significant reduction in limitation, with a major impact on functionality for activities such as turning a key or receiving coins.
Wrist Flexion (Palmar Flexion)	50°	70°	Functional recovery. Regaining complete flexion is essential for the ability to grasp and hold objects.

Table 3 documents the significant improvements in the range of motion for the wrist and forearm over the course of rehabilitation. These gains are not merely a result of stretching stiff joints; they are directly linked to the recovery of muscle strength, the resolution of secondary complications, and the restoration of functional movement patterns [2,10].

Chart 3 - Joint Mobility (Degrees)



The restoration of normal wrist extension (70°) was driven by the strengthened extensor muscles actively pulling the joint through its full range, overcoming periarticular fibrosis [2,6,10]. This is essential for the opening phase of a functional grasp [16]. The dramatic gain in forearm pronation (80°) highlights the therapy's success in addressing secondary contractures of the interosseous membrane and joint capsules, a common consequence of disuse [2,38]. The recovery of full wrist flexion (70°) demonstrates that the program effectively balanced strength training with stretching, maintaining the flexibility of the antagonist muscles and joint, which is crucial for a powerful grasp [4,10].

In conclusion, these results collectively demonstrate the profound capacity for functional restoration in adolescents with radial nerve injuries, even in the chronic phase. The findings validate the structure of the rehabilitation program, which was designed to align with the biological principles of nerve regeneration, capitalizing on the patient's neural plasticity to achieve a comprehensive recovery [2,4,10,27].

4. Discussion

The management of patient U.Ș., a 16-year-old adolescent with a chronic radial nerve injury, constitutes a compelling case for the successful application of a multidisciplinary, evidence-based rehabilitation framework [10,25]. The results demonstrate a significant recovery trajectory that aligns with established principles of neuroregeneration [23,31]. The primary success of this case lies in translating theoretical knowledge into a structured clinical practice that addressed both neurological deficits and secondary complications.

The evolution of functional capacity underscores a transition from impairment to high-level function. The resolution of the "Wrist Drop" sign confirms successful axonal regeneration and reinnervation [10,11]. Furthermore, the remarkable improvement in the 9-Hole Peg Test time reflects recovered fine motor control and dexterity, aligning with evidence that task-specific training promotes cortical reorganisation [4,31].

A key finding was the consistently perfect score on the ABILHAND-KIDS questionnaire, despite initial objective deficits. This highlights the critical distinction between impairment and disability, demonstrating the powerful role of compensatory mechanisms and neuroplasticity [18,19]. However, a notable limitation of the ABILHAND-KIDS in this context is its potential ceiling effect and inability to capture the qualitative compensatory strategies or the increased effort and fatigue associated with task completion. It measures if a task can be done, not how it is accomplished, which may mask underlying inefficiencies.

The progression of muscle strength offers a classic illustration of the proximal-to-distal recovery gradient [6]. The complete normalisation of supinator strength and the significant gains in the finger extensors are a direct result of the phased rehabilitation program, which employed strategies for enhancing motor unit recruitment and muscle fibre hypertrophy [27,31]. The restoration of joint mobility was a direct biomechanical consequence of resolving the interplay between muscle weakness and the sequelae of immobilisation [10, 16, 38].

This case underscores the efficacy of a structured, phased rehabilitation protocol grounded in neuroregeneration principles [22,26]. The systematic use of standardised outcome measures provided an objective framework for monitoring progress and guiding clinical decisions [14,35].

This case report provides a detailed clinical model for achieving excellent functional recovery from a chronic, high radial nerve injury in an adolescent, even when intensive therapy begins as late as nine months post-surgery. It adds to the existing literature by demonstrating that the potential for meaningful neurological and functional improvement extends well beyond the traditionally emphasised early postoperative phase. The study practically illustrates how a structured, individualized, and multidisciplinary physiotherapy program can significantly enhance motor function, muscle strength, and fine motor skills, capitalizing on the patient's inherent neural plasticity.

The limitation of this study is its nature as a single case report. While the results are highly encouraging, they cannot be directly generalized to the broader population of adolescents with radial nerve injuries. Individual factors such as the exact nature of the nerve lesion, surgical technique, patient motivation, and inherent biological differences in healing capacity mean that outcomes can vary significantly. The findings, however, serve as a proof-of-concept and provide a therapeutic framework that can be adapted and tested in larger cohorts.

5. Conclusions

Based on our analysis, several key conclusions can be drawn. First, this case demonstrates that a structured, intensive, and personalised physical therapy program can facilitate a very high level of functional recovery, even when initiated in the chronic phase. The restoration of active wrist extension, normalized muscle strength, and refined fine motor skills validates the efficacy of the methods employed.

Second, the success underscores the paramount importance of an evidence-based and adaptive approach. The use of objective measurement tools enabled precise assessment and guided the progression of therapy, while a combination of therapeutic methods ensured a comprehensive approach to recovery.

Finally, this case strongly supports the value of consistent, specialised rehabilitation. The significant progress achieved in a focused 4-week program for a chronic injury challenges the notion of a strictly limited window for recovery [40], indicating that neural plasticity can be effectively harnessed over extended periods with the right intervention.

In conclusion, the successful outcome for patient U.Ș. was the direct result of a meticulously planned intervention that integrated theoretical principles of nerve healing with practical clinical application [25,34]. It confirms that a positive prognosis is achievable in complex pediatric radial nerve injuries when treatment is evidence-based, patient-centred, and multidisciplinary, ensuring patients not only regain movement but also successfully reintegrate the affected limb into their daily lives [12,24,31]

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