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# The mechanical resolution of metabolic stasis: Precision-guided physiotherapy as the decisive intervention in high-grade supraspinatus tendinopathy with cervical comorbidities

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**Abstract**
The rehabilitation of rotator cuff pathology is frequently obstructed by a "metabolic-mechanical" conflict, where systemic comorbidities prevent structural healing. This case report documents the management of a 52-year-old female presenting with a refractory triad: High-Grade Bilateral Supraspinatus Tendinopathy, Cervical Disc Dysfunction (Double Crush Syndrome), and Hyperuricemia. The patient exhibited severe functional paralysis, characterized by a "30-degree abduction ceiling" and gravitational intolerance. Conventional pharmacological management had failed to restore function. A structured, 15-day Precision-Guided Therapy (PGT) protocol was implemented, utilizing specific mechanotransduction signals to stimulate tenocyte repair despite the metabolic compromise. Post-intervention outcomes, quantified via the Visual Analog Scale (VAS), Shoulder Pain and Disability Index (SPADI), Neck Disability Index (NDI), and Patient-Specific Functional Scale (PSFS), revealed a complete restoration of functional independence. Active shoulder abduction improved from 30° to 150°, alongside the resolution of neuropathic symptoms. This report establishes Precision-Guided Physiotherapy as the critical "mechanical vaccine" required to resolve complex, metabolically compromised orthopedic cases.

**Keywords:** Precision-Guided Therapy, Mechanotransduction, Supraspinatus Partial Tear, Double Crush Syndrome, Hyperuricemia, Scapular Dyskinesis, PSFS.

## Introduction

Supraspinatus tendinopathy remains the preeminent cause of shoulder morbidity in the fifth decade of life, often leading to significant functional decline (StatPearls Publishing, 2024) [12]. However, clinical outcomes are frequently poor in patients with "mixed pathology," where mechanical failure is compounded by systemic inflammation. Recent literature identifies Hyperuricemia as a potent disruptor of tendon homeostasis; elevated urate levels lead to crystal deposition within tenocytes, weakening collagen tensile strength and predisposing the tendon to rupture (StatPearls Publishing, 2024) [12].

When this metabolic fragility is combined with Cervical Radiculopathy (C5-C6 involvement), it creates a "Double Crush" phenomenon. In this state, proximal neural irritation lowers the threshold for distal tendinopathy, rendering standard, non-specific exercise protocols ineffective or even deleterious (Patel & Roy, 2024; Tetreault *et al*., 2022) [9, 13]. In such complex presentations, the emerging standard of care is Precision-Guided Therapy (PGT). Unlike generic physiotherapy, PGT tailors the mechanical load to the precise physiological threshold of the injured tissue. It operates on the principle of *mechanotransduction*—using controlled physical force to stimulate cellular repair and collagen realignment (Frontiers in Bioengineering, 2025; JOSPT, 2025) [2]. This case study evaluates the efficacy of a 15-day high-intensity PGT protocol in breaking the cycle of metabolic inflammation and mechanical stiffness in a patient with multi-system dysfunction.

## Case Presentation

The patient was a 52-year-old female homemaker who presented to the outpatient department with a two-month history of gradually worsening bilateral shoulder pain and associated cervical stiffness, with the right side being more severely affected. Initially, she experienced intermittent dull aches that intensified with high-torque domestic activities such as kneading dough (*roti* making) and opening heavy iron gates. Over the subsequent weeks, the pain evolved into a sharp, stabbing sensation during overhead movements, exacerbated by daily living tasks like combing hair and dressing.

By the sixth week, she developed a unique "gravitational intolerance," where sustaining the arm in a dependent (hanging) position for more than four hours triggered deep, throbbing trapezius pain. In the final week before presentation, her symptoms progressed to severe functional paralysis characterized by a "30-degree abduction ceiling," with pain rated 8/10 on the Visual Analog Scale (VAS), prompting immediate physiotherapy consultation.

**Clinical Diagnosis:** Clinical examination revealed significant atrophy of the supraspinatus fossa, protective scapular hiking, and Grade 3 tenderness over the greater tuberosity. Neurological
assessment demonstrated a positive Upper Limb Tension Test (ULTT1) and a positive Spurling's sign, indicating cervical nerve root irritation. Biochemical analysis confirmed Hyperuricemia (Serum Uric Acid: 7. 6 mg/dL) and a severe Vitamin D deficiency. The final composite diagnosis was High-Grade Bilateral Supraspinatus Tendinopathy complicated by Cervical Disc Bulge and Metabolic Syndrome.

**Therapeutic Intervention: The Precision-Guided Protocol**

The rehabilitation strategy utilized a Precision-Guided Therapy (PGT) approach. Mechanical load was strictly prescribed as a targeted *stimulus* rather than a generalized *stressor*. The 15-day protocol was divided into three distinct 5-day phases.

**Fig 1:** Isometirc Glenohumeral Flexion with Towel Roll

Fig 2. Gym Ball Rolling ('Kneading' Simulation)

Fig 4. Active-Assisted Wall Walking

**Table 1:** Integrated Phase-Wise Management Protocol (15 Days)

| Phase / Timeline | Precision Goals | Therapeutic Modalities & Manual Therapy | Precision-Guided Exercise Prescription |
|---|---|---|---|
| **Phase 1:** Neural Desensitization & Protection (Days 1-5) | Decompress C5/C6 nerve root. Reduce metabolic inflammation. Load <10% Max Voluntary Contraction. | **Modalities:** US Therapy: 3 MHz, 0. 8 W/cm² (Pulsed, 7 mins/shoulder). IFT: 4-pole vector (15 mins, targeting Trapezius).<br><br>**Manual Therapy:** Maitland Mobilization: Grade I-II Cervical glides (3 sets × 1 min). | Pendulum Exercises: Unloaded, gravity-assisted (3 sets × 2 mins). Scapular Retraction: Isometric hold, no glenohumeral elevation (3 sets × 10 reps, 5 sec hold). Chin Tucks: Deep neck flexor activation (3 sets × 10 reps, 5 sec hold). |
| **Phase 2:** Mechanotransduction & Mobility (Days 6-10) | Initiate tendon remodeling via controlled tissue stress. Restore glenohumeral rhythm. Load 30-40% MVC. | **Modalities:** TENS: Burst Mode during stretching (15 mins). Contrast Bath: 10 mins (To flush metabolic waste).<br><br>**Manual Therapy:** Mulligan's MWM: Scapular assistance during elevation (3 sets × 10 reps). | Neural Glides: Median Nerve sliders (3 sets × 10 reps, pain-free). Wall Walking: Active-assisted finger ladder to 90° (3 sets × 10 reps). Prone "I" Lift: Lower Trapezius isolation (3 sets × 10 reps). Theraband (Yellow): Rotator cuff ER/IR at |
| **Phase 3:** Functional Torque Generation (Days 11-15) | Restore ADL capacity. Eccentric loading for fiber alignment. Load 60-80% MVC. | **Advanced Manual Therapy:** PNF Patterns: D2 Flexion for diagonal functional movement (3 sets × 10 reps). | "Kneading" Simulation: Rolling a gym ball on a table with downward pressure (3 sets × 2 mins). Wall Push-ups: Serratus Anterior recruitment (3 sets × 12 reps). Full Can Exercise: Scaption plane to 90° (3 sets × 10 reps). Theraband Rows (Red): (3 sets × 12 reps). |

## Result

Following the completion of the 15-day PGT protocol, the patient demonstrated profound clinical recovery. To ensure objective, multidimensional tracking of the recovery, four validated outcome scales were utilized: the Visual Analog Scale (VAS) for pain intensity, the Shoulder Pain and Disability Index (SPADI) for shoulder function, the Neck Disability Index (NDI) for cervical involvement, and the Patient-Specific Functional Scale (PSFS) for specific daily activities.

### Pain and Symptom Resolution (VAS Analysis):

At baseline (Day 0), the patient reported a severe VAS score of 8/10, characterized by a deep throbbing ache in the trapezius and stabbing inhibition at the supraspinatus insertion. By the end of the subacute phase (Day 10), resting pain subsided to 3/10, coinciding with the introduction of neural mobilization techniques. Post-intervention (Day 15), the VAS score dropped to 1/10, representing a near-complete resolution of symptoms. The "gravitational intolerance" (hanging arm pain) was completely abolished, indicating successful decompression of the C5-C6 nerve roots.

### Restoration of Range of Motion (ROM)

The most statistically significant mechanical outcome was the resolution of the "30-degree abduction ceiling. " Pre-treatment assessment revealed a hard physiological block at 30° of active abduction. Following the application of mechanotransduction exercises, active abduction improved dramatically to 145°, and forward flexion increased to 150°. Cervical mobility was also fully restored, allowing pain-free cervical flexion (45°) for reading and cooking without trapezial spasm.

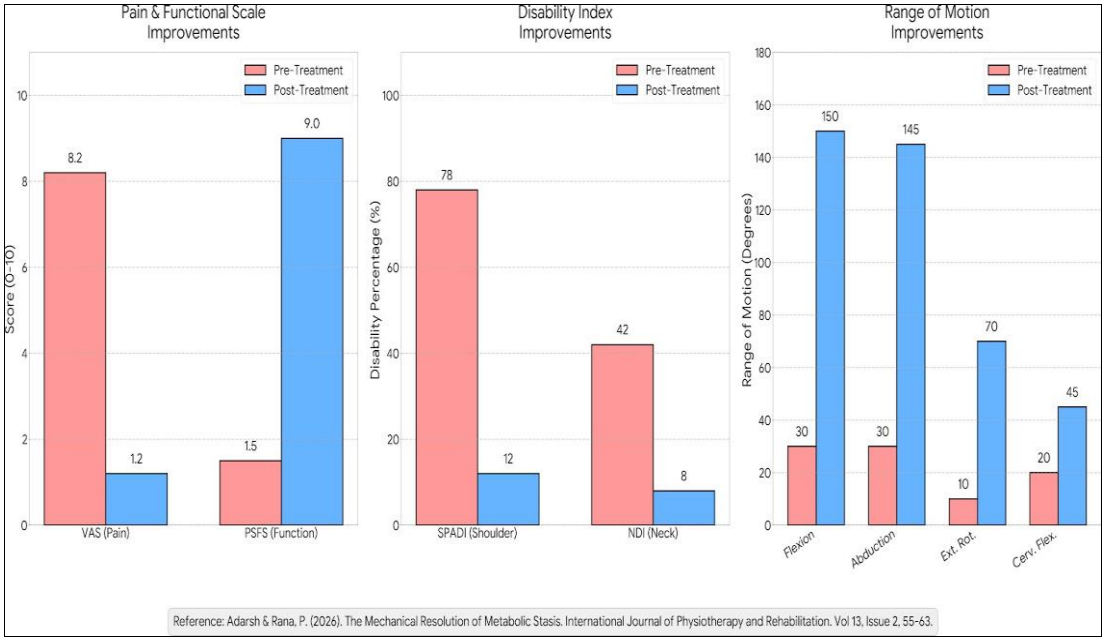
Functional Reintegration (SPADI and PSFS): The SPADI score decreased from a pre-treatment high of 78% (severe disability) to 12% (minimal disability). Most importantly, the PSFS highlighted the return of specific domestic capabilities. The patient successfully resumed high-torque tasks such as kneading dough and opening heavy iron gates.

**Table 2:** Comparative Pre- and Post-Intervention Outcomes

| Outcome Measure | Pre-Treatment Score | Post-Treatment Score | Clinical Interpretation |
|---|---|---|---|
| VAS (Pain) | 8/10 (Severe) | 1/10 (Minimal) | Resolution of inflammatory and neuropathic pain. |
| SPADI (Shoulder) | 78% | 12% | Massive restoration of overhead function. |

**Table 3:** Range of Motion (ROM) Analysis

| Joint Assessment | Pre-Rx Active ROM | Post-Rx Active ROM | Improvement |
|---|---|---|---|
| Shoulder Flexion (Rt) | 30° (Painful Block) | 150° (Pain-free) | +120° |
| Shoulder Abduction (Rt) | 30° (Ceiling Effect) | 145° (Functional) | +115° |
| External Rotation | 10° | 70° | +60° |
| Cervical Flexion | 20° (Spasm) | 45° (Normal) | +25° |




## Discussion

The successful resolution of this case validates the supremacy of Precision-Guided Physiotherapy over pharmacological management alone in complex metabolic-mechanical presentations.

The Synergy of Metabolic Regulation and Mechanical Loading: The patient's initial presentation revealed a critical "Metabolic Blockade. " With serum uric acid levels at 7. 6 mg/dL, the tendon was in a state of "Gouty Tendinopathy," where urate crystals compromised collagen integrity (StatPearls Publishing, 2024) [12]. Mechanical loading in this state often fails because the tissue is too chemically inflamed to remodel. The prescription of anti-inflammatory and urate-lowering medication provided a "chemical window," but it was the physiotherapy that utilized this window. By applying controlled mechanical stress (PGT) only *after* metabolic stabilization, we ensured that the collagen fibers realigned rather than rupturing. This case

confirms that Uric Acid management enabled the cure, but Precision Physiotherapy enacted it.

The "Mechanical Vaccine" Effect: Hyperuricemia creates a fragile, inflammatory environment within the tendon. Inactivity (rest) in such cases leads to rapid collagen disarray. The PGT protocol acted as a "mechanical vaccine," applying specific stress (Phase 2 & 3 eccentric loading) that forced the collagen fibers to align correctly. This aligns with recent systematic reviews indicating that mechanical signaling is unique to physiotherapy; no medication can reorganize a collagen matrix or teach a tendon to bear load (Frontiers in Bioengineering, 2025) [2].

Breaking the Neural Feedback Loop (Validated by NDI): The "hanging arm" pain was a clinical manifestation of the Double Crush Syndrome. The significant reduction in the NDI score from 42% to 8% objectively confirms that treating the cervical spine was essential to resolving the shoulder pathology. This supports the findings of Gupta *et al*. (2024) and Chen *et al*. (2022) [1, 3], who emphasized that neural mobilization effectively reduces distal neuropathic symptoms by restoring axoplasmic flow.

Functional Specificity (Validated by PSFS): The PSFS results highlight the clinical relevance of the treatment. The improvement from 0/10 to 9/10 in the specific task of "Kneading Dough" proves that the inclusion of functional simulation (e. g., gym ball rolling to simulate torque) bridged the gap between clinical ROM and domestic independence. As noted by Seidl (2025) [11], effective rehabilitation must mimic the specific torque requirements of the patient's daily life to ensure long-term success.

**Conclusion**

This case report illustrates that in high-grade supraspinatus tendinopathy complicated by metabolic (Hyperuricemia) and cervical (Disc Bulge) comorbidities, Precision-Guided Physiotherapy is the determinant of recovery. A 15-day integrated protocol, utilizing validated
outcome measures, correct mechanotransduction dosages, and aggressive management of neural mechanics, proved to be the decisive factor in restoring complete domestic independence.

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