SPMRJ. Volume 4 No. 2 August 2022
SINTA 5 (Decree No: 200/M/KPT/2020)
DOI: 10.20473/spmrj.v4i2.32836
Available online at https://e-journal.unair.ac.id/SPMRJ

Case Report

Sonography and EMG Biofeedback's Role in PIN Syndrome After Rehabilitation? A Case Report

Evi Rachmawati Nur Hidayati[1*], Zuliza Adha[1], Hafizia Asri Yusviani[1], Savira Widha Alifprilia[1]

[1]*Department of Physical Medicine and Rehabilitation, Universitas Indonesia Hospital, Universitas Indonesia, Depok, West Java, Indonesia*

*Corresponding Author:
Evi Rachmawati Nur Hidayati, Department of Physical Medicine and Rehabilitation, Universitas Indonesia Hospital, Universitas Indonesia, Depok, West Java, Indonesia.
E-mail: Evir96@gmail.com

Article info:
Received: January 12nd, 2022;
Received in revised: March 22nd, 2022;
Accepted: March 22nd, 2022;
Published: August 22nd, 2022.

Cite this as:
Hidayati ERN, Adha Z, Yusviani HA, Alifprilia SW. Sonography and EMG Biofeedback's Role in PIN Syndrome After Rehabilitation? A Case Report. *SPMRJ*. 2022;4(2):90-97.

ABSTRACT

The radial nerve divides into two terminal branches the superficial radial nerve and the posterior interosseous nerve. Posterior interosseous nerve entrapment is associated with weakness in the extension of fingers, atrophy of the forearm muscles, and localized pain in the lateral aspect of the elbow and proximal forearm without sensory deficits. A 37-year-old man complained of difficulty of right finger extension (MMT 2) and persistent pain (VAS 5) at the forearm after a fall from a motorcycle six months before admission. We treated the patient with a physical rehabilitation program for three months and a total of 12 visits. Sonography and electromyography (EMG) biofeedback were performed to evaluate improvement after the physical rehabilitation program. After three months, the pain was relieved, and forearm extensor muscle strength increased. This showed that sonography and EMG biofeedback play a role in the detection and evaluation of muscle and nerve abnormality due to posterior interosseous nerve (PIN) syndrome.

Keywords: *Posterior Interosseous Nerve Syndrome, Case Report, Rehabilitation, Sonography, Electromyography Biofeedback.*

Introduction

The radial nerve runs beneath the long radialis carpal extensor and the short radialis carpal extensor at the elbow. The radial nerve divides into two terminal branches—the superficial radial nerve and the posterior interosseous nerve.[1] The majority of posterior interosseous nerve innervation is the motor branch of the nerve fiber located in the forearm. Some muscles located in the forearm are the supinator, the short radial carpal extensor muscles, the common digital extensor muscle, the digiti minimi extensor, the ulnar carpal extensor, the pollicis abductor, the short pollicis extensor, the long pollicis extensor, and the indicis extensor innervated by posterior interosseous nerve (PIN).[2]

PIN compression occurs within the musculotendinous radial tunnel. Posterior interosseous nerve compression is associated with weakness in the extension of fingers, atrophy of muscles in the forearm, and without sensory deficit.[3] There may be a history of episodic forearm pain followed by progressive weakness of the extensors of the fingers as well as the short radial carpal extensor. Symptoms may occur because of trauma (penetrating, tendon rupture, iatrogenic), space-occupying lesions, and inflammatory conditions (rheumatoid arthritis, mononeuritis).[2] Radial nerve compression, such as radial tunnel and posterior interosseous nerve syndromes, result in a decreased quality of life and ability to perform daily activities.[4]

Evaluation of PIN abnormality can be performed through sonography and electromyography (EMG) biofeedback examination before and after rehabilitation. Sonography examination includes nerve swelling, compression, changed echogenicity, displacement, and the presence of a mass originating from or around the PIN.[5] Nerve swelling or compression is identified as an increase in nerve diameter just before the supinator muscle and needs to be compared to the contralateral asymptomatic nerve. Further confirmation of nerve abnormality function uses EMG biofeedback to optimize the physical rehabilitation program. EMG biofeedback is one of the therapeutic techniques that use physiological electrical response through visual and auditory signals.

Sonography has become a valid method for the imaging of peripheral nerves, and it has proven to be especially valuable in the imaging of compression neuropathy.[6] EMG biofeedback has become an efficient tool for the identification and assessment of neuropathy diseases as well.[7] However, only a few case reports, reviews, and case series describing sonography findings and EMG biofeedback in the evaluation of PIN syndrome are available in the literature, and further work is required. Hence, the purpose of this case report was to assess whether sonography and EMG biofeedback play a role in the evaluation of PIN syndrome after the comprehensive physical rehabilitation program.

Material & Method (Case Report)

A 37-year-old man experienced difficulty of right finger extension and persistent pain (VAS 5) at the forearm after falling from a motorcycle six months before admission. The patient was a potter, Javanese, body mass index (BMI) was normal and without previous medical history. On physical examination, there was difficulty in extending the right fingers with an average muscle strength of 2. The patient had undergone nerve exploration and neurolysis PIN operation with orthopedic surgery two months after admission. After the surgery, there was an 8 cm wound found at the anterolateral forearm without significant pain; hence, there was no sensory deficit along the forearm to the hand. We also performed hand function examination using the Disabilities of the Arm, Shoulder, and Hand (DASH) questionnaire and obtained a score of 59 before rehabilitation.

Comprehensive physical rehabilitation was performed for three months, three times in a week, by giving Low-Level Laser Therapy (LLLT), active and passive strengthening exercise of the common digital extensor and long pollicis extensor muscles using neuromuscular electrical stimulation (NMES), and a static hand splint to avoid muscle contracture. The evaluation of nerve and muscle function was performed before and after rehabilitation using sonography imaging and EMG biofeedback.

Result

After three months of physical rehabilitation, there was improvement of extensor muscles contraction from MMT 2 to 4. However, patient still complained reduce of sensibility on area innervated by superficial radial nerve. Figure 1a shows the radiography of the right radius-ulnar bone in AP projection. Malunion of one-third proximal ulnar can cause soft tissue edema on the fracture site and lead to posterior interosseous nerve compression. Figure 2a–c exhibits muscle strength of the common digital extensor of the right hand before rehabilitation, the average strength of which was MMT 2, accompanied by persistent pain, swelling, and redness of the forearm. The patient had difficulty moving all fingers from flexion to extension position. Figure 2d–f exhibits the improvement of muscle strength from MMT 2 to MMT 4, and functionally the patient can do grips, grasp, finger extension, and adduction of the right finger after three months of physical rehabilitation.

Figure 3a and 3b show normal sonography findings of PIN around the arcade of Frohse, below the supinator muscle. Compared with Figures 3a and 3b, Figures 3c and 3d showed the enlargement of the right PIN diameter with hypoechoic appearance. Furthermore, a decrease in nerve diameter and hyperechoic feature were shown in the sonography examination after physical rehabilitation.

Figure 4a and 4b show amplitude of EMG biofeedback on common digital extensor muscle before and after rehabilitation. Figure 4a, indicated low amplitude of muscle contraction (showed in red graph) by averaged in 70µv and still far compared with the baseline amplitude (showed in green graph). Figure 4b, indicated the increased of muscle contraction showed by higher amplitude by average in 130µv (red graph) and parallel with baseline amplitude.

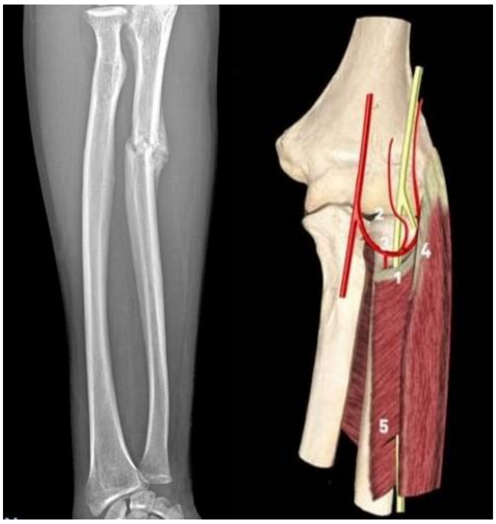
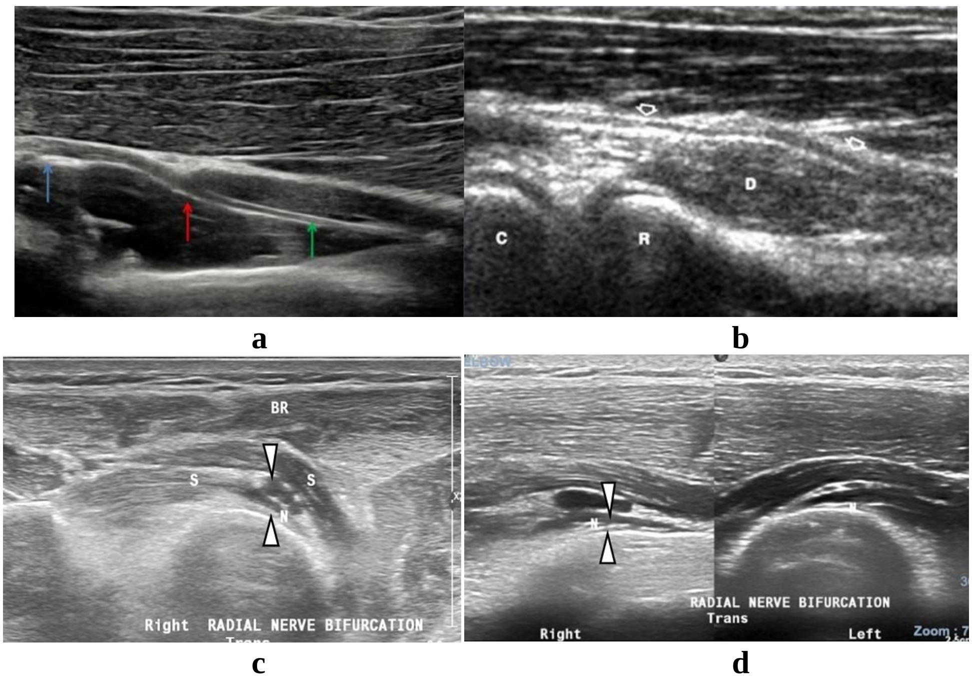
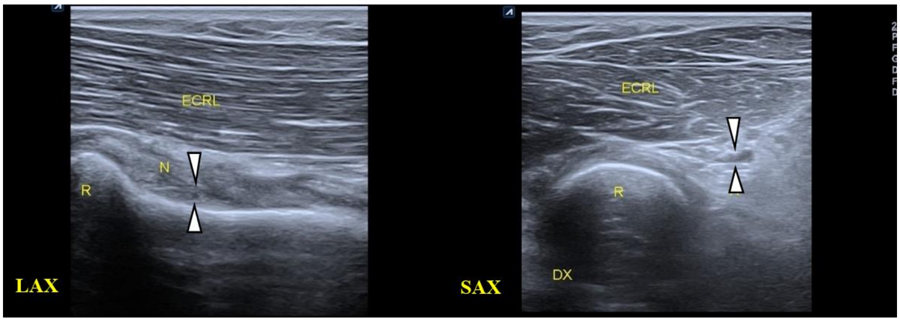


Figure 1. (a) Malunion (R) of one-third proximal ulnar bone, (b) projection of the posterior interosseus nerve on one-third proximal ulnar bone.

Figure 2. (a–c) Physical examination of common digital extensor muscle strength before rehabilitation; (d–f) physical examination of common digital extensor muscle strength after rehabilitation.





e f

Figure 3. (a, b) Normal sonography finding of posterior interosseous nerve syndrome in the forearm at the arcade of Frohse level which in Figure 3a is marked with an upward-facing arrow.[8] ; (c, d) sonography of PIN syndrome at the right elbow before rehabilitation; (e, f) sonography of PIN syndrome at the right elbow after rehabilitation; N=PIN (marked with white arrow); ECRL= extensor carpi radialis longus; BR = Brachio-radialis muscle; R = Os Radius;LAX = Long Axis; SAX = Short Axis

a b

Figure 4. EMG biofeedback before rehabilitation (a) and after rehabilitation (b). *Device used was Neuro-Trac® EMG biofeedback

Discussion

The difficulty to extend the right fingers (muscle strength was 2), particularly the digiti minimi extensor muscle, followed by persistent pain (VAS 5) at the forearm is characteristic of PIN syndrome. There are some other common findings like a weakness of other extensor muscles in the hand such as the radial extensor carpi muscle and the thumb extensor muscle that resembles that of our patient, with no sensory deficit.[2] Weakness of the extensor muscles and pain resulting from posterior interosseous nerve entrapment are due to trauma that leads to soft tissue edema at the fracture site.[3] Nerve compression often occurs in the lateral intermuscular septum, the short carpal radialis extensor margin, and the distal ligamentous margin of the supinator muscle. Meanwhile, the most common area of compression is the arcade of Frohse as fibro-tendinous band from which some muscle fibers originate.[2,4]

Nerve entrapment syndrome is commonly diagnosed using nerve conduction study or needle EMG and the use of high-resolution ultrasonography to evaluate anatomical appearance.[6] EMG plays a role in establishing the electrophysiologic severity of the lesion.[5] There are two types of EMG measurement: surface and intramuscular.[9] Surface EMG is noninvasive and has been widely used for superficial, large, and easily accessible muscles.[10] However, EMG biofeedback is currently used as a new method to evaluate the presence of muscle functional disorder and perform muscle retraining by creating new feedback systems.[11] It detects skeletal muscle activity and converses myoelectrical signals in the muscle into visual and auditory stimuli.[12] This technique records a difference in potential electrical activity along the length of a muscle using electrodes over the skin surface.[11]

The use of EMG biofeedback in the peripheral nerve system is considerably due to its contribution to muscle strengthening and recruitment as reinnervation takes over.[13] EMG biofeedback can be used either to increase activity in weak or paralyzed muscles or facilitate a tone reduction in spastic ones. Compared to conventional therapy, EMG biofeedback results in greater improvements in functional features such as muscle force, active range of movement and motor recovery.[12] Studies on EMG biofeedback indicated that patients with sensorimotor deficits were able to control single-muscle activation based on their EMG responses. Two mechanisms might occur: either new pathways are developed or the feedback loop recruits existing cerebral and spinal pathways. In addition, visual and auditory feedback suggests the activation of unused synapses in executing motor functions. Overall, biofeedback may enhance neural plasticity by using both auditory and visual inputs, thus making it a plausible tool for neurorehabilitation.[14] After the application of various modalities in rehabilitation, the amplitude recorded on the EMG biofeedback for this patient increased during muscle contraction.

PIN entrapment might be difficult to assess clinically because it exhibits various features such as painless palsy or painful condition depending on the site of entrapment.[2] Electro-diagnostics could not identify the exact site of nerve compression.[4] However, sonography can be used as an additional examination to determine the exact location of nerve abnormality, so that might increase the accuracy of examination and thus increase the success of the rehabilitation program.[8] Sonography examination was performed bilaterally to evaluate the anteroposterior (AP) of the PIN diameter. The measurement is preferably performed at three locations in the long axis at three different locations including the entry point of the arcade, 5 mm upstream and 5 mm downstream the arcade of Frohse. The echo-structure of the nerve was analyzed in terms of echogenicity and fasciculation. The normal PIN features were described as having a honeycomb appearance without an increase in echogenicity and a normal diameter (0.49–1.16 mm). Meanwhile, the sonographic findings in PIN syndrome would be an abnormal nerve swelling and a change in its diameter at the entrapment site[8]. Our patient showed consistent findings with a previous study that exhibited an enlargement of the right PIN diameter with hypoechoic appearance, which was significantly greater (2 mm) compared with that of normal people (1 mm). The other study showed similar results, which found an AP diameter of 1.79 mm in the affected hand and 1.02 mm in the healthy hand (P=0.003).[15]

The improvement of PIN syndrome was achieved after a comprehensive physical rehabilitation program for three months. The rehabilitation program included LLLT, strengthening of the common digital extensor and long pollicis extensor muscles using NMES, and static hand splint. LLLT has been widely used and suggested to reduce inflammation and tissue edema, relieve pain, and promote the healing of musculoskeletal injury. It works by the mechanism of photo-stimulation to the mitochondria, leading to the activation of signaling pathways, thus increasing growth factors, promoting neovascularization and angiogenesis, demonstrating its ability to heal the nerves, and stimulating the proliferation of Schwan cells, the principal glial cells of the peripheral nervous system, resulting in the acceleration of nerve regeneration.[16,17] To increase muscle strength, we performed both active and passive strengthening exercises. Passive strengthening was performed by giving NMES aimed to improve muscle weakness. This technique used a lightweight stimulator unit and skin electrodes to produce a controlled and comfortable muscle contraction.[18] Direct electrical stimulation enhanced sensory and motor axon regeneration, accelerated functional recovery, and facilitated the reinnervation of the injured nerves.[19] Meanwhile, the role of active strengthening exercises in the nervous system was observed in axonal growth, phenotypic changes in peripheral structures and neuro-tropine levels. Several studies have investigated the impact of physical exercise on peripheral nerve regeneration and functional recovery.[20,21] During the regeneration period, increased motor activity by exercise also positively influences neuromuscular functional outcomes after nerve injury.[22,23] The additional therapeutic method was the static hand splint, which aimed to immobilize the wrist in a neutral position to avoid flexion or extension contraction of the wrist, keep denervated muscles from remaining in an overstretched position, prevent joint contractures, and maximize the functional use of the hand.[24] There is no adverse events (dangers) or unexpected events were identified along this treatments.

The evaluation of the rehabilitation program for this patient was assessed by MMT measurement, presented the function of innervated muscles by DASH score, and was confirmed by sonography and EMG biofeedback. The DASH questionnaire provided evaluations of hand function and ability in general by assessing the severity of disability in hand function through the scores that can be obtained by the patient.[25] Comprehensive physical rehabilitation programs not only relieved the symptoms but also increased muscle function as seen in the improvement of EMG biofeedback and decreased edema in sonography examination.

Conclusion

In conclusion, improvement of PIN syndrome after the rehabilitation program was not only explained clinically by pain relief and increased muscle strength but also confirmed by the improvement of EMG biofeedback and USG features. Therefore, the use of USG and EMG biofeedback provided a tremendous diagnosis and evaluation of physical rehabilitation programs through posterior interosseous nerve syndrome.

Acknowledgement

We would like to thank the staff of Physical and Medical Rehabilitation Unit, Universitas Indonesia Hospital, Depok for their supports in this case report.

References

1. Cha J, York B, Tawfik J. Posterior Interosseous nerve compression. Eplasty 2014; 14: ic4.
2. Cho Tae-Koo KJ-MBK-HKC-H. Posterior Interosseous Nerve (PIN) Syndrome Caused by Anomalous Vascular Leash. J Korean Neurosurg Soc 2005; 37: 293–295.
3. Silver S, Ledford CC, Vogel KJ, et al. Peripheral Nerve Entrapment and Injury in the Upper Extremity. Am Fam Physician 2021; 103: 275–285.
4. Ong C, Nallamshetty HS, Nazarian LN, et al. Sonographic Diagnosis of Posterior Interosseous Nerve Entrapment Syndrome. Radiology Case Reports 2007; 2: 1–4.
5. Roquelaure Y, Raimbeau G, Dano C, et al. Occupational Risk Factors for Radial Tunnel Syndrome in Industrial Workers. Scandinavian Journal of Work, Environment & Health 2000; 26: 507–513.
6. Djurdjevic T, Loizides A, Löscher W, et al. High Resolution Ultrasound in Posterior Interosseous Nerve Syndrome. Muscle & Nerve 2014; 49: 35–39.
7. Duarte-Moreira RJ, Castro KV-F, Luz-Santos C, et al. Electromyographic Biofeedback in Motor Function Recovery After Peripheral Nerve Injury: An Integrative Review of the Literature. Applied Psychophysiology and Biofeedback 2018; 43: 247–257.
8. Ceri T, Podda A, Behr J, et al. Posterior interosseous nerve of the elbow at the arcade of Frohse: Ultrasound appearance in asymptomatic subjects. Diagnostic and Interventional Imaging 2019; 100: 521–525.
9. Farina D, Negro F. Accessing the Neural Drive to Muscle and Translation to Neurorehabilitation Technologies. IEEE Reviews in Biomedical Engineering 2012; 5: 3–14.
10. Péter A, Andersson E, Hegyi A, et al. Comparing Surface and Fine-Wire Electromyography Activity of Lower Leg Muscles at Different Walking Speeds. Frontiers in Physiology; 10. Epub ahead of print October 10, 2019. DOI: 10.3389/fphys.2019.01283.
11. Woodford HJ, Price CI. EMG biofeedback for the recovery of motor function after stroke. Cochrane Database of Systematic Reviews; 2010. Epub ahead of print April 18, 2007. DOI: 10.1002/14651858.CD004585.pub2.
12. Giggins OM, Persson U, Caulfield B. Biofeedback in rehabilitation. Journal of NeuroEngineering and Rehabilitation 2013; 10: 60.
13. Novak CB. Rehabilitation Following Motor Nerve Transfers. Hand Clinics 2008; 24: 417–423.
14. Huang H, Wolf SL, He J. Recent developments in biofeedback for neuromotor rehabilitation. Journal of NeuroEngineering and Rehabilitation 2006; 3: 11.
15. Kim Y, Ha DH, Lee SM. Ultrasonographic findings of posterior interosseous nerve syndrome. Ultrasonography 2017; 36: 363–369.
16. B Cotler H. The Use of Low Level Laser Therapy (LLLT) For Musculoskeletal Pain. MOJ Orthopedics & Rheumatology; 2. Epub ahead of print June 9, 2015. DOI: 10.15406/mojor.2015.02.00068.
17. Wang C-Z, Chen Y-J, Wang Y-H, et al. Low-Level Laser Irradiation Improves Functional Recovery and Nerve Regeneration in Sciatic Nerve Crush Rat Injury Model. PLoS ONE 2014; 9: e103348.
18. Jones S, Man WD-C, Gao W, et al. Neuromuscular electrical stimulation for muscle

weakness in adults with advanced disease. Cochrane Database of Systematic Reviews; 2016. Epub ahead of print October 17, 2016. DOI: 10.1002/14651858.CD009419.pub3.

19. Ju C, Park E, Kim T, et al. Effectiveness of electrical stimulation on nerve regeneration after crush injury: Comparison between invasive and non-invasive stimulation. PLOS ONE 2020; 15: e0233531.

20. Saratsiotis J, Myriokefalitakis E. Diagnosis and treatment of posterior interosseous nerve syndrome using soft tissue manipulation therapy: A case study. Journal of Bodywork and Movement Therapies 2010; 14: 397–402.

21. Maugeri G, D'Agata V, Trovato B, et al. The role of exercise on peripheral nerve regeneration: from animal model to clinical application. Heliyon 2021; 7: e08281.

22. Navarro X, Vivó M, Valero-Cabré A. Neural plasticity after peripheral nerve injury and regeneration. Progress in Neurobiology 2007; 82: 163–201.

23. Marqueste T, Alliez J-R, Alluin O, et al. Neuromuscular rehabilitation by treadmill running or electrical stimulation after peripheral nerve injury and repair. Journal of Applied Physiology 2004; 96: 1988–1995.

24. Halac G, Demir S, Yucel H, et al. Splinting is effective for night-only symptomatic carpal tunnel syndrome patients. Journal of Physical Therapy Science 2015; 27: 993–99625.

25. Gummesson C, Atroshi I, Ekdahl C. The disabilities of the arm, shoulder and hand (DASH) outcome questionnaire: longitudinal construct validity and measuring self-rated health change after surgery. BMC Musculoskeletal Disorders 2003; 4: 11.