

High - Resolution Ultrasound: A Transformative Tool for Diagnosing Traumatic Peripheral Neuropathies

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Abstract: Traumatic peripheral nerve injuries present significant diagnostic challenges due to their diverse presentations and potential long - term impacts. This study evaluates the utility of high - resolution ultrasonography (HRUS) in diagnosing and managing such injuries. Conducted at a tertiary care center, this cross - sectional observational study examined 30 patients with suspected nerve injuries. Findings reveal HRUS's capacity to identify critical morphological changes like neuromas, nerve thickening, and transections, enabling timely and precise therapeutic interventions. This research underscores HRUS's transformative potential in improving clinical outcomes for peripheral neuropathies. **Aims & Objectives:** This study aims to assess the diagnostic capabilities of high - resolution ultrasonography in identifying and classifying traumatic peripheral neuropathies, thereby improving patient outcomes through targeted interventions. **Materials & Methods:** This cross sectional observational study conducted in Department of Radiodiagnosis, Sri Lakshmi Narayana Institute of Medical Sciences, Pondicherry. Patients referred from the Orthopedics and Emergency departments with clinical suspicion of peripheral neuropathies constituted the study population. **Results:** The study group included 30 individuals referred to the Department of Radiology for USG examination due to suspected peripheral nerve injuries ranging in age from 20 to 68 years of which, 45% of patients had neuroma, 30 % patients had thickening of peripheral nerve, 25 % patients had partial or complete nerve transection. **Conclusion:** Ultrasound represents a powerful tool in enabling appropriate planning for treatment, preventing unnecessary surgery where conservative management is sufficient and thus improving overall outcomes in patients with peripheral neuropathy.

Keywords: high - resolution ultrasound, traumatic neuropathies, nerve injuries, ultrasonography, peripheral nerves

1. Introduction

Traumatic peripheral neuropathies, caused by mechanical, metabolic, or ischemic insults, represent a significant clinical challenge due to their debilitating effects on motor, sensory, and autonomic functions. Early and accurate diagnosis is crucial for determining the extent of nerve injury and formulating appropriate treatment strategies. Over the years, diagnostic modalities for peripheral nerve injuries have evolved, with electrodiagnostic studies serving as a traditional cornerstone. However, these methods often fail to provide detailed morphological insights into nerve structure and surrounding tissues (1, 2).

High - resolution ultrasonography (HRUS) has emerged as a transformative imaging modality, offering real - time visualization of peripheral nerves with exceptional spatial resolution. Unlike electrodiagnostic studies, HRUS provides both static and dynamic imaging capabilities, enabling clinicians to assess nerve continuity, fascicular patterns, and surrounding structures with high accuracy (1). Furthermore, its non - invasive nature, cost - effectiveness, and portability make it an indispensable tool in the diagnosis and management of peripheral neuropathies (2).

HRUS has been particularly beneficial in identifying entrapment neuropathies and traumatic nerve injuries, where early detection and characterization of the lesion are paramount. Studies, including those by Bianchi et al. and Koenig et al., have demonstrated HRUS's ability to depict nerves along their anatomical course, identify subtle changes such as nerve swelling or hypoechogenicity, and evaluate

the impact of extraneural structures like callus or scar tissue (1, 2).

The study emphasizes the critical role of HRUS in enhancing diagnostic accuracy, reducing unnecessary surgical interventions, and informing effective treatment strategies for traumatic nerve injuries.

2. Materials & Methods

- This cross sectional observational study was conducted in Department of Radiodiagnosis, Sri Lakshmi Narayana Institute of Medical Sciences, Puducherry.
- Patient population: 30 Individuals aged 20 to 68 Years

Inclusion criteria:

- For the purposes of this study, Peripheral N injury was defined as an injury to a major nerve in the upper (i. e., radial, median, or ulnar nerve) or lower (i. e., sciatic, femoral, peroneal, or tibial nerve) limb.
- Patients referred from Orthopedics department & Emergency department with history of trauma & clinical suspicion of peripheral neuropathies.

Exclusion criteria:

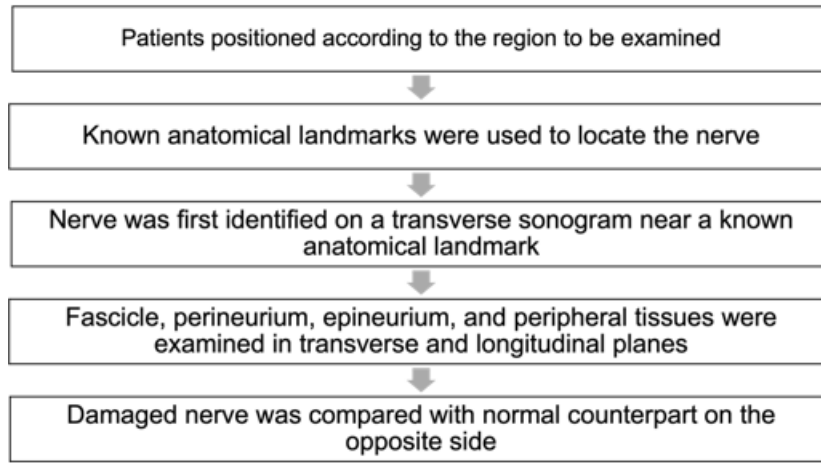
- Patients with exclusively nerve root, plexus (brachial or lumbar), digital, or any other minor nerve injury were excluded.

Ultrasound was performed with 6 - 14 MHz linear - array transducers.

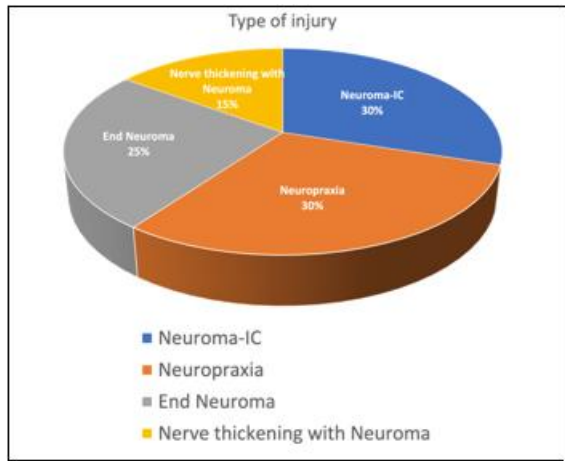
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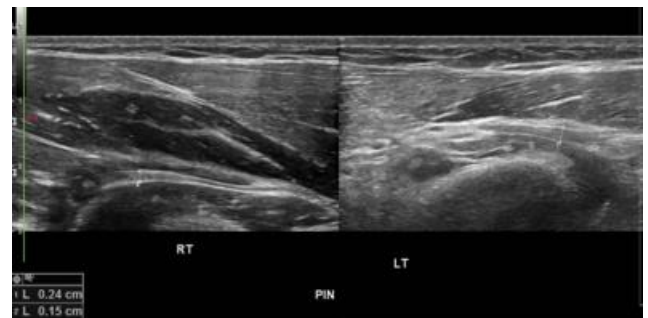
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3. Results



- The mean age of the population was 44.4 years, with a range of 20 to 68.
- The majority (33.3%) of the population was between the ages of 20 and 30 years. The ratio of males to females was 2: 1, with 33 % of the patients being male.

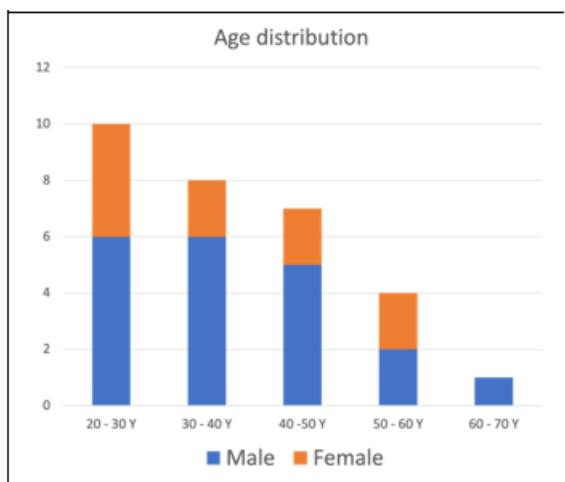


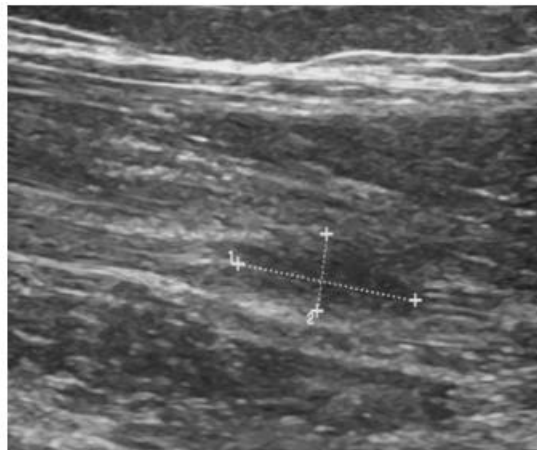
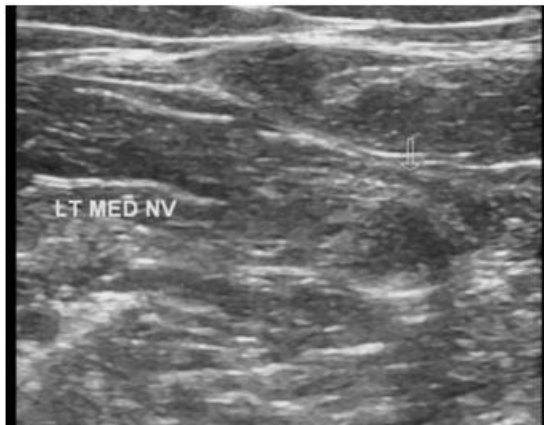
- Among the 30 individuals in the study population,
- Neuropraxia & neuroma in continuity (30%) was the most common type of injury identified on high resolution US.
- Nerve transection (End Neuromas) was seen in 25% of patients which was very important in determining the treatment & outcome of management.
- 15% patients had both thickening of peripheral nerve & neuroma IC.

- Long segment diffuse hypoechoic thickening of the left posterior interosseous nerve without any discontinuity - - - s/o neuropraxia.

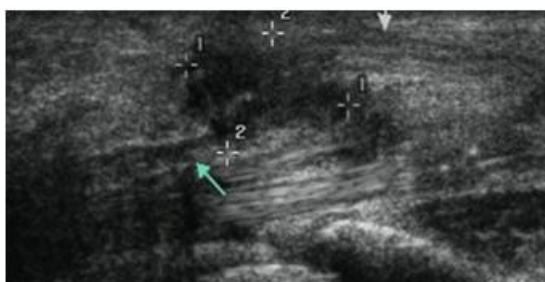


- The radial nerve in the distal arm, near the cubital fossa, displays mild contour alterations and diffuse thickening with loss of normal fasciculations for ~ 5 cm - ? neuroma in continuity/ neuropraxia.





- A focal hypoechoic lesion [$\sim 8 \times 3.5$ mm] causing mild contour abnormality in the left median nerve near the scar site (~ 3 cm inferior and medial to the scar site in the proximal 1/3rd of forearm) - s/o focal neuroma.



- A longitudinal section of the ulnar nerve in the forearm reveals a focal hypoechoic lesion - S/o Traumatic neuroma

4. Discussion

The results of this study reinforce the growing body of evidence supporting the use of high - resolution ultrasound (HRUS) in the assessment of traumatic peripheral neuropathies. Several studies have demonstrated HRUS as an effective tool for diagnosing and monitoring nerve injuries, offering valuable insights into the morphology of the injured nerve and aiding in treatment planning.

In the study by Zhu et al., involving 202 patients aged 17 to 64 with traumatic peripheral nerve injuries, ultrasound successfully evaluated the type of traumatic injuries and monitored morphological changes in the injured nerve, particularly the inner structures. This ability to track the progression of nerve injury over time is essential for determining appropriate management strategies, as the nature of the injury—such as whether it is a neuropraxia, axonotmesis, or neurotmesis—dictates the course of treatment. HRUS was instrumental in differentiating these injuries, which is consistent with the findings of the current study, where distinct patterns of nerve thickening and neuromas were observed. ⁽³⁾

Similarly, the prospective study by Padua et al., which involved 98 patients aged 8 to 79 years with traumatic nerve lesions, demonstrated that ultrasound altered the diagnosis or therapeutic approach in 60% of cases. This finding underscores ultrasound's role in providing crucial diagnostic information that other modalities, such as

neurophysiological evaluations, may not reveal. Particularly, HRUS was able to identify the etiology and precise sites of damage, which is critical for surgical planning. The study's results align with our observations where ultrasound not only helped in identifying nerve injuries but also aided in determining the site of neuromas and nerve transections, which are essential for surgical decision - making. Additionally, ultrasound's capacity to visualize even very small nerves, often challenging for other imaging techniques, enhances its utility in assessing minor or less obvious traumatic injuries. ⁽⁴⁾

The study by Cokluk et al. further supports the role of ultrasound in evaluating peripheral nerve injuries, especially in detecting both early and late - phase injuries. In their study of 36 patients with traumatic upper extremity injuries, ultrasound findings were compared with surgical results, and the correlation was excellent. This dynamic ability of HRUS to detect the morphological changes during different stages of injury makes it invaluable for timely intervention, as early identification of nerve pathologies can significantly improve treatment outcomes. ⁽⁵⁾

Furthermore, a case series by Bodner et al. on four patients with accessory nerve palsy illustrates ultrasound's ability to detect nerve transections and scar tissue formation, both of which are challenging to assess through clinical examination alone. HRUS was particularly successful in visualizing atrophy of the trapezius muscle as an indirect indicator of nerve injury. This finding highlights the potential of ultrasound not only to identify the direct nerve damage but also to observe the secondary effects of nerve dysfunction, such as muscle atrophy, which provides additional diagnostic value. ⁽⁶⁾

Overall, the evidence from these studies, combined with the findings of this study, demonstrates that HRUS is an effective and valuable tool in the evaluation of traumatic peripheral neuropathies. It offers several advantages over traditional diagnostic modalities, including its non - invasive nature, real - time imaging, and ability to visualize the intricate details of nerve anatomy and pathology. Moreover, it is a cost - effective and accessible alternative to more expensive and less widely available imaging techniques like

MRI. As such, HRUS is poised to become an essential component in the diagnostic and therapeutic management of traumatic peripheral nerve injuries, enabling better planning, earlier intervention, and improved patient outcomes.

5. Conclusion

High - resolution ultrasonography represents a pivotal advancement in the evaluation of traumatic peripheral neuropathies. By enabling precise identification of injury types, HRUS optimizes treatment strategies, reduces unnecessary interventions, and improves patient care outcomes. Future research should focus on standardized protocols to further integrate HRUS into routine clinical practice

References

- [1] Koenig RW, Pedro MT, Heinen CP, Schmidt T, Richter HP, Antoniadis G, Kretschmer T. High - resolution ultrasonography in evaluating peripheral nerve entrapment and trauma. *Neurosurg Focus*.2009 Feb; 26 (2): E13. doi: 10.3171/FOC.2009.26.2. E13. PMID: 19435442.
- [2] Bianchi S, Montet X, Martinoli C, Bonvin F, Fasel J. High - resolution sonography of compressive neuropathies of the wrist. *J Clin Ultrasound*.2004 Nov - Dec; 32 (9): 451 - 61. doi: 10.1002/jcu.20065. PMID: 15558623.
- [3] Zhu J, Liu F, Li D, Shao J, Hu B. Preliminary study of the types of traumatic peripheral nerve injuries by ultrasound. *Eur Radiol*.2011 May; 21 (5): 1097 - 101. doi: 10.1007/s00330 - 010 - 1992 - 3. Epub 2010 Oct 24. PMID: 20972875.
- [4] Padua L, Di Pasquale A, Liotta G, Granata G, Pazzaglia C, Erra C, Briani C, Coraci D, De Franco P, Antonini G, Martinoli C. Ultrasound as a useful tool in the diagnosis and management of traumatic nerve lesions. *Clin Neurophysiol*.2013 Jun; 124 (6): 1237 - 43. doi: 10.1016/j. clinph.2012.10.024. Epub 2013 Feb 4. PMID: 23380690.
- [5] Cokluk C, Aydin K. Ultrasound examination in the surgical treatment for upper extremity peripheral nerve injuries: part I. *Turk Neurosurg*.2007 Oct; 17 (4): 277 - 82. PMID: 18050073.
- [6] Bodner G, Harpf C, Gardetto A, Kovacs P, Gruber H, Peer S, Mallhoui A. Ultrasonography of the accessory nerve: normal and pathologic findings in cadavers and patients with iatrogenic accessory nerve palsy. *J Ultrasound Med*.2002 Oct; 21 (10): 1159 - 63. doi: 10.7863/jum.2002.21.10.1159. PMID: 12369671.