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# Frequency and Pattern of Peripheral Nerve Involvement in Firearm Injuries: A 10-year Neurophysiology Lab Experience

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## ABSTRACT

**Introduction:** To determine the frequency, pattern, and severity of peripheral nerve involvement in firearm-related injuries based on electrophysiological studies. To explore the frequency of surgical interventions performed after firearm-related nerve injuries.

**Methods:** This was a retrospective cross-sectional study conducted in the neurophysiology department at the Aga Khan University Hospital (AKUH), Karachi, Pakistan. The study included all the patients with gunshot injuries and underwent two Electromyography and Nerve conduction studies (EMG/NCS) at least 8 weeks apart for follow-up. The data was analyzed by SPSS version 22.0.

**Results:** Out of a total of 216 patients, firearm injury was seen most frequently in the lower limb 56.5% (n=122) mainly the Sciatic nerve 26.6% (n=54) followed by upper limb 35.6% (n=77) mainly brachial plexus 19.2% (n=39). Axonal-type nerve injury without evidence of reinnervation (i.e. severe) was the most frequent electrophysiological finding 79.8% (n=162).

**Conclusions:** Firearm injury in limbs is associated with significant morbidity. The study describes various patterns and severity of firearm-related peripheral nerve injuries. Electrophysiological studies aid in localizing and assessing the severity of post-traumatic nerve injury further guiding the prognosis and candidacy of surgical intervention.



**Keywords:** *Firearm injuries; Gunshot; Neuropathy; Neurolysis; Nerve grafting.*

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## INTRODUCTION

Gun violence, from armed robbery and hate crimes to school shootings and warfare, is a pressing public health issue. Karachi, due to its strategic location, handles complex gunshot cases from across Pakistan and neighboring countries like Afghanistan and Iran. Peripheral nerve damage in gunshot injuries may result from direct nerve transection, shockwave transmission, compression by dislocated bone or bullet fragments, hematoma, aneurysm, or compartment syndrome. Electrophysiological studies play a key role in diagnosing, assessing severity, and localizing nerve injuries, with follow-up studies enhancing accuracy.

Early identification and intervention in post-traumatic nerve injury can enable full recovery within six months [1-2]. Local epidemiological data on firearm-related peripheral nerve injuries are limited to small-scale studies in scattered areas of Pakistan [3-5], highlighting young males (20-40 years) as primary victims [6-7]. The injury site varies, with the trunk and extremities being most frequently affected [4,6-7].

This study aimed to analyze the nature and extent of these injuries using electrophysiological methods.

## METHODS

This hospital-based retrospective cross-sectional study was conducted at Aga Khan University Hospital Neurophysiology Department. The duration of the study was 10 years. After receiving approval from the Institutional Ethical Committee (reference ID: 2022-7468-21540), data was collected on a pre-specified questionnaire from the hospital database of patient records including the demographic details and EMG-NCS results. The sampling technique used was non-randomized consecutive sampling.

All patients who underwent Electromyography and Nerve conduction studies (EMG-NCS) between 1st January 2012 to 31st December 2021 (and another follow-up study after at least 8 weeks) were included in the study. Certified neurophysiologists interpret EMG-NCS studies. The data included demographic details and results of EMG-NCS.

Operational definitions: The degree of severity of peripheral nerve injury on an electrophysiological basis (as derived from Robinson L. R.) [8] is given below:

Demyelinating type: refers to the presence of conduction block, focal slowing or temporal dispersion, prolongation of latencies, and slowing of conduction velocity without significant reduction of amplitudes in nerve conduction studies in acute stage with or without electromyography showing only significant reduction of interference pattern with minimal spontaneous activity and normal morphology of motor units. The follow-up studies indicate significant improvement in the above-mentioned parameters.

Axonal type with evidence of reinnervation (as per follow-up study after at least 8 weeks of gunshot injury): refers to significant reduction in the amplitudes of sensory or motor nerve responses in nerve conduction studies in acute stage and with interval improvement of the parameters in follow-up study with or without electromyography showing significant spontaneous activity with severely reduced recruitment in acute stage and follow-up study shows high broad motor units with polyphasia and satellite potentials to indicate reinnervation.

Axonal type without evidence of reinnervation: (as per follow-up study after at least 8 weeks of gunshot injury): refers to severe reduction or absence of amplitudes of sensory or motor nerve responses in nerve conduction studies in acute and chronic phases without any improvement with or without Electromyography showing significant spontaneous activity with no motor unit action potentials (hence no polyphasic motor units or satellite potentials) in both acute or chronic phase after firearm injury to indicate reinnervation.

## RESULTS

There were 216 cases of firearm injuries visiting the neurophysiology department for diagnostic purposes. Most cases were male (n=202) 93.5% while only patients 6.5% (n=14) were female. The mean age distribution was 32 ± 11.6 years with a wide range from 6 years to 72 years. Multiple gunshot injuries to the limbs were observed in only 2 cases. 203 out of 216 patients (94%) showed abnormalities in EMG NCS testing (Table 1). Regarding the distribution of injury, lower limbs (n=122) 56.5% were the most common site followed by upper limbs (n=77) 35.6%. (Table 1)

**Table 1: Characteristics and Pattern of Firearm Injuries (n=216)**

| **Characteristics** | **Frequency n (%)** |
|---|---|
| Lower Limb | 122 (56.5%) |
| Upper limb | 77 (35.6%) |
| Neck | 10 (4.6%) |
| Back | 4 (1.9%) |
| Face | 3 (1.4%) |

Most electrophysiological findings were unilateral (n=183) 90.1% and severe i.e., axonal-type nerve injury without evidence of reinnervation (n=162) 79.8%. Demyelinating type and axonal type nerve injury with evidence of reinnervation comprised 41% of the cases combined (Table 2).

**Table 2: Laterality and Types of Neuropathies (n=203)**

| Characteristics | Frequency n (%) |
|---|---|
| Unilateral | 183 (90.1%) |
| Bilateral | 20 (9.9%) |
| Demyelinating | 9 (4.4%) |
| Axonal type with evidence of reinnervation | 32 (15.7%) |
| Axonal type without evidence of reinnervation | 162 (79.8%) |

Less frequent patterns were plexopathies (n=51) 25.1% and multiple mononeuropathies (n=39) 19.2%. One case of cauda equina syndrome related to gunshot injury was also seen (Table 3). The most common nerve involved was the sciatic nerve (54 cases out of 86), 63%. Three cases of facial nerve injury were also observed. Mononeuropathies (42.4%) were the most frequently observed pattern of injury (Table 3).

**Table 3: Pattern of Neuropathies (n=203)**

| Characteristics | Frequency n (%) |
|---|---|
| Mononeuropathy | 86 (42.4%) |
| Plexopathy | 51 (25.1%) |
| Multiple Mononeuropathies | 39 (19.2) |
| Radiculopathy | 26 (12.8%) |
| Cauda Equina Syndrome | 1 (0.5%) |

Brachial plexopathy in the form of involvement of trunk, roots and cords was found to be more common (39 out of 51 cases of plexopathies) (Table 4) among plexopathies.

**Table 4: Detailed Pattern of Mononeuropathies (n=86) and Plexopathies (n=51)**

| Mononeuropathy | Frequency n | Plexopathy | Frequency n |
|---|---|---|---|
| Sciatic | 54 | Brachial Plexus (trunk) | 16 |
| Radial | 6 | Brachial Plexus (roots) | 8 |
| Ulnar | 6 | Brachial Plexus (cords) | 15 |
| Femoral | 4 | Lumbosacral Plexopathy (L2-S1) | 1 |
| Facial | 3 | Lower Lumbosacral Plexopathy (L5-S1) | 2 |

Lumbosacral radiculopathy, commonly observed at the level of L5-S1 was seen in 77% (20 out of 26 cases of radiculopathies) of gunshot related to radiculopathies (Table 5).

**Table 5: Detailed Pattern of Mononeuropathies and Radiculopathies**

| Multiple Mononeuropathies (n=39) | Frequency (n) | Radiculopathy (n=26) | Frequency |
|---|---|---|---|
| Peroneal and tibial mononeuropathies | 13 | Lumbosacral Radiculopathy | 20 |
| Sciatic and femoral mononeuropathies | 4 | L5-S1 radiculopathy | 15 |
| Other nerves (Lower Limb) | 8 | Others | 5 |
| Median, Ulnar and Radial Nerves | 12 | Cervical Radiculopathy (C5-C7) | 6 |
| Other nerves (Upper Limb) | 2 | | |

## DISCUSSION

Ballistic injuries lead to significant mortality and disability. Firearms are the most common weapons of violence in a study conducted in Karachi published in 2002 [9]. Gunshot wounds show a non-uniform pattern of nerve damage either in continuity or in a mixed pattern [10]. Amongst the multi-system involvement, the Peripheral nervous system in the form of brachial and lumbar plexopathy, mononeuropathies and polyneuropathy has been reported in the literature [11].

A study by Razaq S. et al. demonstrated 418 patients with war-related injuries in soldiers. Blast injury (48.5%) was the main mechanism followed by gunshot injury (43% cases) [3]. Characteristics of nerve injury specifically attributed to gunshot injury were not described in the study but overall, the most injured nerve was the ulnar (20.6%) followed by sciatic (16.7%) nerves. This frequency shows reciprocity in our study with sciatic (26.6%, 54 out of 203 cases) being the most common followed by ulnar nerve (2.9%, 6 out of 203 cases). The brachial plexus was more frequently involved in our study (around 19%) compared to 8.5% of cases. Regarding the severity of nerve injury, Razaq S. et al. observed axonotmesis as a major degree (i.e., 91%) of nerve injury while a more severe degree i.e., Neurotmesis was more frequent (about 80% cases) in our study. Neuropraxia secondary to bullet injury was infrequent in both studies [3].

Another study conducted in a public hospital in Peshawar Pakistan, described 40 cases of patients with peripheral nerve injury. Gunshot injury (57.5%) was the main mechanism of injury followed by iatrogenic injury although nerve injury specific to gunshot injury was not separately described. The ulnar nerve was the most frequently involved (i.e., 20%) followed (in 10% cases each) by median, radial, sciatic, and common peroneal nerves again contrasting with our study. The brachial plexus was injured in 12.5% of cases which is like our study. Recovery of the peripheral nerves after trauma, is variable depending on various factors alongside surgical intervention if timely performed [12].

A comprehensive study based on data of 40 years duration on peripheral nerve injury caused by gunshot injury in Gülhane Military Medical Academy, Istanbul, Turkey depicted converse results compared to our study. The most frequently wounded nerve was the median nerve (27.37%), followed by the ulnar (18.41%), sciatic (12.12%), and radial (11.53%) nerves. Most of the injuries were axonotmesis similar to older military series which were axonotmesis [13].

Eckhoff MD, in his article, highlighted peroneal nerve injury as the most common injured nerve [13] as opposed to our findings. The peroneal nerve is said to be very susceptible to traumatic injury [13]. Cindro VV et al in an article mentioned a higher frequency of single peripheral nerve involvement in firearm-afflicted wounds (80%), and findings similar to our results. Again, peroneal was common among mononeuropathy to be affected [14].

Therefore, firearm injuries do not only cause emotional damage but also affect physically, sometimes leading to permanent physical disability if not intervened at the appropriate time. If clinically correlation and intervention can be done at an appropriate time, recovery can be anticipated earlier with relatively good outcomes at appropriate time (12,15)

The limitations of our study include its single-center design with a predominance of outpatient diagnostic referrals, which restricted our ability to follow the long-term course and management of the cases.

**CONCLUSIONS:**

Firearm injury in limbs is associated with significant disability. The study describes various patterns and severity of firearm-related peripheral nerve injuries. Electrophysiological studies aid in localizing and assessing the severity of post-traumatic nerve injury, further guiding the prognosis and candidacy of surgical intervention.

**CONFLICT OF INTEREST:** NONE

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