

# Traumatic Peripheral Nerve Injuries: Demographic and Electrophysiologic Findings of 802 Patients from a Developing Country

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## Abstract

### Objective:

To study a series of patients with traumatic peripheral nerve injury during the past 10 years in Cerrahpasa Medical Faculty/Istanbul/Turkey.

### Methods:

The chart review of 802 patients was evaluated and we explored the type(s) and cause(s) of injury, and electromyographic findings. The study included 171 children and 631 adults and we excluded the patients who suffered from injuries due to the Marmara earthquakes that occurred in 1999.

### Results:

Injury was most common in the upper extremities in both children (78.36%) and adults (63.54%). The common causes of nerve injury in children were as follows: obstetric lesions (46.78%), iatrogenic lesions (16.95%), traffic accidents (15.7%), and sharp lacerations (12.8%), whereas the commonest cause of nerve injury in adults was due to sharp lacerations (27.57%), followed by iatrogenic lesions (25.67%), and traffic accidents (23.77%). The most commonly injured nerves were the brachial plexus and ulnar nerve in children and adults, respectively. Electromyography demonstrated that complete nerve injury predominated in both groups.

### Conclusions:

If preventive measures are taken into consideration satisfactorily, the incidence of disabling peripheral nerve injury may decrease, as such injuries are often treatable.

**Key Words:** electromyography, peripheral nerve injury, trauma

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Trauma is the leading cause of death between 1 and 44 years of age, and is

the third after cancer and cardiovascular disorders among all age groups. More than 11 million people die every year in the world, trauma being responsible for 8% of deaths.<sup>1</sup> Although preventive measures including first aid have been taken during the past years in our country, there is still an unacceptably high incidence of both preventable trauma and death.<sup>2</sup>

Peripheral nerve injuries (PNI) are common and encompass a wide spectrum of diseases in neurologic and neurosurgical practice, as they are sometimes disabling and are often treatable. The general agreement is that they, particularly in the younger population, often result from motor vehicle accidents or high velocity trauma, leading to disabling and devastating neurologic dysfunction.

In our increasingly violent society, injuries to the peripheral nerves, including the brachial plexus, constitute a major medical and public health problem. Despite dramatic advances in surgical techniques and an increased awareness of the importance of nerve grafting in peripheral nerve repair, the long-term prognosis in patients with severe nerve injuries remains gloomy.

Even though it is possible clinically to identify the site of injury in many patients with PNI, it is not possible to localize the site of the injury accurately, particularly when multiple nerves are involved. In such cases, electrodiagnostic studies are invaluable in

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localizing the site(s) of nerve injury. Electrodiagnostic studies constitute the most objective and quantitative means of evaluating and sequentially following patients with traumatic PNIs. They can be used to localize the lesions, determine the underlying pathology, estimate the extent and severity of the axonal degeneration, and follow recovery.<sup>3-6</sup>

This is one of few studies<sup>7</sup> providing demographic data related to traumatic PNI from Turkey, a developing country, and is the first to try to establish knowledge about PNI in Istanbul, the most crowded city in Turkey. This study does not include the patients who suffered from PNI owing to the earthquakes that occurred in the Marmara region of Turkey and the results related to PNI that were reported previously.<sup>8,9</sup>

Advancement in radiologic and electrophysiologic diagnostic techniques led us to detect extends and understand the mechanism(s) of PNI more accurately; and progress in instrumentation and microsurgical techniques have improved our management of major PNI. However, despite the improvements, the incidence of PNI remains high, and preventive measures will be beneficial to decrease such injuries, which may cause life-long disabling neurologic dysfunction. Searching the literature demonstrates that the etiologic factors leading to PNI vary from country to country, depending on, at least we think, the developmental state of the country. Thus, it seems reasonable to provide demographic, clinical, etiologic data to prevent injury and manage patients. This study aims to focus on such issues as those mentioned above and to contribute to the current literature.

## MATERIALS AND METHODS

We conducted a retrospective review of the clinical, demographic, and electromyographic (EMG) data in patients with traumatic PNI in the past 10 years. Ethical

approval for this study was obtained from the Human Investigations Committee at Istanbul University. This study included 171 (21.32%) children and 631 (78.67%) adult patients. Demographic data, cause(s) of injury, the nerve injured, time from injury to initial EMG examinations, and EMG findings were reviewed. The patients, who had motor weakness, sensory loss, paresthesia, and pain due to trauma, were referred from the clinics in our hospital or regional hospitals and trauma centers.

A detailed history of trauma was taken from all patients. Muscle strength tests, sensory tests, and deep tendon reflexes were assessed during neurologic examination. EMG examination was carried out with 3 different devices Neuropack  $\Sigma$  (Nihon Kohden, Tokyo, Japan), Counterpoint (Dantec, Slovlunde, Denmark), and Key-point (Dantec, Slovlunde, Denmark), using similar protocols.<sup>4,5,10</sup> The level and severity of the lesion were noted and localizations of the lesions were determined for the spinal root, plexus, and peripheral nerves in the nerve conduction studies (NCV), and the presence of denervation and regeneration was assessed by needle EMG with standard techniques.<sup>4,5,10</sup> Lesions that involved to more than one nerve and did not fit any plexus region were assessed as multiple nerve injury. We practically excluded neuropathic injuries by including the patients who had abnormal EMG findings at 4 weeks after injury. Thus, axonotmesis and neurotmesis in different stages of denervation or reinnervation were evaluated.<sup>11</sup>

PNIs in this study were classified electromyographically as partial nerve injuries (PaNI) and complete nerve injuries (CNI). Criteria related to PaNI were assumed as follows: (a) spontaneous and volitional activity of the muscle in the EMG: rare or no fibrillation potentials and positive sharp waves, loss of motor units depending on degree of volitional movements, polyphasic potentials, and prolonged duration of the mean potential; (b) electrical stimulation of the nerve trunk with derivation of muscle

potentials: compound motor action potentials (CMAPs) with diminished amplitude, prolonged latency, and temporal dispersion; (c) motor conduction velocity: slow MCV; and (d) recording of the sensory nerve action potential (SNAP) after stimulation of the nerve trunk or the sensory fibers of the nerves in the skin of the fingers: SNAPs with absent or diminished amplitude, temporal dispersion, and decreased conduction velocity. CNI criteria also were assumed as follows: (a) spontaneous and volitional activity of the muscle in the EMG: fibrillation potentials and positive sharp waves, no volitional activity; (b) electrical stimulation of the nerve trunk with derivation of muscle potentials: no elicited CMAP with stimulation distal to the lesion; (c) no elicited motor summation potentials; and (d) recording of the nerve action potential after stimulation of the nerve trunk or the sensory fibers of the nerves in the skin of the fingers: no SNAP obtained except for root avulsions.<sup>6</sup>

## RESULTS

Of 171 children, 60 (35.08%) were girls and 111 (64.91%) were boys with a mean age of  $7.88 \pm 4.95$ , ranging from 0 to 16 years. Adult population composed of 176 (27.89%) female and 455 (72.10%) male subjects with a mean age of  $38.23 \pm 15.64$ , ranging from 17 to 86 years. Upper extremities were more commonly affected than lower extremities in both groups, and facial

injury was seen only in the adult population. Table 1 summarizes demographic data belonging to both groups.

When considering the cause(s) of PNI, we found that obstetric and iatrogenic lesions were the leading causes of injury in children and adults, respectively. Traffic accidents and sharp lacerations were found to be other common causes in both groups (Table 2).

In children, brachial plexus injury predominated (50.29%). Of 86 brachial plexus injuries, involvement of the whole trunk was seen in 40, upper trunk only in 18, lower trunk only in 4, upper plus middle in 18, and middle plus lower in 6 pediatric patients. Except for the brachial plexus injury, ulnar, median, and radial nerves were commonly injured in the upper extremities in children.

In adults, the ulnar nerve injury (17.59%) is the most common type, followed by injuries to the median nerve (12.67%), radial nerve (10.14%), and brachial plexus (9.82%). In the lower extremities, the sciatic nerve was the most commonly affected nerve in both children (14.03%) and adults (11.88%). In addition, the fibular (8.08%) and femoral (1.58%) nerves were the second and the third nerves commonly injured in adults, respectively. In contrast to the pediatric age group, the number of adults who suffered from facial nerve injury is acceptable. The higher numbers of ulnar, median, and radial nerve injuries in the upper extremities were not

TABLE 1. The Demographic Data of the Pediatric and Adult Age Groups

Parameters	Pediatric Age	Adult Age	Total
Number	171 (12.32%)	631 (78.67%)	802
Mean age (y)	$7.88 \pm 4.95$	$38.23 \pm 15.64$	
F/M	60/111	176/455	236/566
Upper extremity	134 (78.36%)	401 (63.54%)	535
Lower extremity	36 (21.05%)	195 (30.90%)	231
Upper and lower	1 (0.58%)	3 (0.47%)	4
Right face	0	15 (2.37%)	15
Left face	0	15 (2.37%)	15
Perineum	0	2 (0.31%)	2

**TABLE 2.** Etiological Factors of the Pediatric and Adult Age Groups

Cause	Pediatric Age	Adult Age	Total
Obstetric lesion	80 (46.78%)	16 (2.53%)	96
Iatrogenic	29 (16.95%)	162 (25.67%)	191
Traffic accident	27 (15.78%)	150 (23.77%)	177
Sharp laceration	22 (12.86%)	174 (27.57%)	196
Falling down	5 (2.92%)	24 (3.80%)	29
Burn injury	3 (1.75%)	6 (0.95%)	9
Sports injury	2 (1.16%)	14 (2.21%)	16
Gunshot wound	1 (0.58%)	44 (6.97%)	45
Electric shock	1 (0.58%)	6 (0.95%)	7
Amputation	1 (0.58%)	0	1
Occupational accident	0	33 (5.22%)	33
Suicide	0	2 (0.31%)	2

surprising because these nerves run beside bone or across a joint, making injury more likely. Multiple nerve injuries were also common in adults (Table 3).

The sciatic nerve and brachial plexus injury in both groups mainly resulted from injections of medication and obstetric lesions, respectively. We included injections of medication, routine venipuncture, intraoperative positioning, and angiographic studies of iatrogenic lesions and among them, we found that the injection of medi-

cation was responsible for more PNI. The second most common cause of PNI in the iatrogenic group was surgical procedures or conditions. Orthopedic surgery was responsible for most injuries.

As seen in Table 4, most of the patients in both the pediatric (97.66% of 171) and adult (94.61% of 631) population showed CNI on EMG. The mean time elapsed from injury to initial EMG examinations was  $34.52 \pm 50.26$  (15 d to 180 mo) and  $24.81 \pm 67.25$  (15 d to 450 mo) months

**TABLE 3.** Distribution of Injury Among the Nerves in Both Pediatrics and Adults

Nerve Injured	Pediatric Age	Adult Age	Total
Median	9 (5.26%)	80 (12.67%)	89
Ulnar	17 (9.94%)	111 (17.59%)	128
Radial	6 (3.50%)	64 (10.14%)	70
Axillary	1 (0.58%)	5 (0.79%)	6
Musculocutaneous	0	1 (0.15%)	1
Suprascapular	0	1 (0.15%)	1
Long thoracic	0	1 (0.15%)	1
Brachial plexus	86 (50.29%)	62 (9.82%)	148
Spinal root	1 (0.58%)	4 (0.63%)	5
Fibular	6 (3.50%)	51 (8.08%)	57
Tibial	1 (0.58%)	5 (0.79%)	6
Sural	0	1 (0.15%)	1
Femoral	0	10 (1.58%)	10
Lumbar plexus	1 (0.58%)	2 (0.31%)	3
Lat. Cutan. Femoral	0	1 (0.15%)	1
Sciatic	24 (14.03%)	75 (11.88%)	99
Facial	0	31 (4.91%)	31
Pudental	0	2 (0.31%)	2
Accessory	0	5 (0.79%)	5
Sacral plexus	1 (0.58%)	1 (0.15%)	2
Multiple	18 (10.52%)	114 (18.06%)	132

**TABLE 4.** Summary of EMG Findings According to the Types of Injury

Parameters	Pediatric Age	Adult Age	Total
Time elapsed (mo)	34.52 ± 50.26	24.81 ± 67.25	
EMG			
PaNI	4 (2.33%)	34 (5.38%)	38
CNI	167 (97.66%)	597 (94.61%)	764

in the pediatric and adult population, respectively.

## DISCUSSION

PNIs commonly are the direct consequences of contusion, strain, and compression due to trauma, heat, electric shock, and injection of medication. Injury and contusion often result from penetrating injuries, open/closed bone fractures, and gunshot wounds.<sup>12</sup> The demographic data belonging to PNIs may show variations in both mechanism(s) and type(s) of injury, because the developmental stage of a country, including education of public and authorized personnel and preventive measures to decrease traffic accidents, such as roads built to suitable standards and appropriate sports, have an influence on the incidence of PNIs. The results of this study, from a developing country, are consistent with the literature and demonstrate that men are more commonly affected than women and that the upper extremities are the commonly traumatized parts of the body. Additionally, trauma to the face, accompanying by facial nerve injury, was encountered in adults, the majority of which was due to traffic accidents.

One of the intriguing findings in this series is that iatrogenic lesions are the second leading cause after sharp laceration in adults. Vascular injuries that may contribute to PNI are increasing in parallel to the advancement in percutaneous endovascular diagnostic and therapeutic procedures.<sup>2</sup> There is enough information in the literature pertaining to PNI caused by iatrogenic lesions.<sup>13-15</sup> It is beyond the scope of this

paper to explain the types of iatrogenic lesions in detail. Suffice it to say that we should have an in-depth knowledge of peripheral nerve anatomy and educate people about it to avoid such injuries, which may cause devastating life-long damage.

Traffic accidents are an other leading cause of PNI in the current study. Traffic accidents, as in many countries of the world, constitutes a major problem that remains to be solved in Turkey, and despite the vigorous preventive measures, including roads built to suitable standards and laws, the number of injuries occurring as a result of traffic accidents has not decreased during the past 10 years.<sup>16-18</sup> According to the World Health Organization, 41,345 people died and 3,200,000 people became disabled due to motor vehicle accidents.<sup>19</sup> It was reported in 2002 that 2900 people died and 94,225 people were injured due to traffic accidents in 1999 in our country.<sup>2</sup> Therefore, it is important to note that most of the PNI can be prevented through proper education.

Traffic accidents, falls from a height, and burns are the main reasons leading to trauma in children. Birth injury and child abuse are 2 conditions, that have a special role in these age groups. Brachial plexus injuries due to birth injury commonly involve the right side, and C5-6 is the commonest level affected.<sup>20</sup> The most common cause of PNI in children was due to obstetric lesions in this series. The pediatric population in this series showed 50.29% of brachial plexus injury, 51.16% and 53.48% of which occurred on the right and left side, respectively. Most (41.8%) of the brachial plexus

injury involved the upper trunk. Infants born with an obstetric lesion of the brachial plexus, who show signs of recovery within 2 to 3 months of life but have inadequate recovery, have also been reported.<sup>21</sup> Unfortunately, most of the children with PNI due to birth injury and abdomino-pelvic surgery showed inadequate recovery and CNI in our data. In our opinion, the most important factor responsible for delayed referral was the lack of awareness in either the treating surgeon or the children's families.

In their series, Kauder et al<sup>22</sup> demonstrated that the leading cause of PNI in the older age group is falls from a height, followed by traffic accidents and assaults. However, we found traffic accidents to be the main cause of PNI, followed by assaults and falls in people over 60 years of age. It has been demonstrated that lacerations such as those created by a knife blade are a common cause of PNI, comprising 30% of serious injuries in some series.<sup>23</sup> Sharp laceration in the current series, consistent with the literature, constituted the majority of causes leading to PNI in adults. Gunshot wounds caused PNI in 6.9% of adults evaluated in this series and constituted a surgical dilemma in treatment because this type of wound causes extensive crushing, tearing, and contusion.

The peripheral nerve has an extremely limited repertoire of pathologic process to injury, regardless of the evoking mechanism. If the brunt of the injury is borne by the axon, Wallerian degeneration occurs, whereas if the Schwann cell or myelin is injured, segmental demyelination results. The pathologic equivalent of segmental demyelination is neuropraxia. Prognosis for recovery from neuropraxic injury is excellent as remyelination proceeds and function returns completely, usually within a period of days or weeks.<sup>3-5</sup> In practice, pure neuropraxia due to trauma is rare; thus it is rarely examined in the EMG laboratories. In contrast, the majority of traumatic nerve lesions belong to either axonotmesis or neurotmesis.<sup>3,5</sup>

With PaNI, the needle EMG shows minimal fibrillations and positive spike waves, a considerable number of motor unit potentials (MUPs) associated with an increased proportion of polyphasic MUPs, and reduced recruitment of MUPs on maximal contraction. NCV showed a slow motor NCV with decreased amplitude of the CAMP and an absent SNAP or slow sensory NCV.<sup>5</sup> On the other hand, in the case of CNI, one observes a failure to elicit any CMAPs with supramaximal stimulus, an absence of SNAPs, and numerous fibrillations associated with positive sharp waves. No MUP is seen on needle EMG even on maximal contraction.<sup>5</sup> Regrettably, most of our patients showed CNI (95.26%) on EMGs mainly due to delayed referral of the patients to be examined electrophysiologically. As the previous publications stated, early detection of PNI means early treatment, which in turn results in good outcome.<sup>24,25</sup> Therefore, a physician's awareness of PNIs is vital to the diagnosis and to appropriate treatment.

## LIMITATIONS OF THE STUDY

The authors, want to underline that this paper aims to provide demographic information related to PNIs from a developing country in a simple manner and to contribute to the previous papers. One of the limitations of the study is that it is a retrospective chart review. Also, it would be more beneficial to give data related to treatment modalities and control EMG findings of these patients.

## CONCLUSIONS

This study found that the majority of PNI is avoidable if preventive measures, including mainly education, are taken into consideration earnestly. Once the injury occurs, however, it is imperative to recognize it, as timely treatment may be the only hope for recovery in the majority of patients with PNI.

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