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# The Investigation of Electrodiagnostic Findings in Patients with Nerve Injury Due to Earthquake: Single Centre Experience

## Deprem Nedeni ile Sinir Hasarı Olan Hastaların Elektrodiagnostik Bulgularının İncelenmesi: Tek Merkez Deneyimi

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**ABSTRACT**

**Aim:** This study aimed to evaluate neuromuscular damage in the patients affected by the earthquakes that struck Kahramanmaraş, Türkiye.
**Material and Methods:** Patients referred to the electrodiagnostic (EDx) laboratory between February and August 2023, who were trapped under rubble, were included in this study. Demographic data, clinical information (renal failure, serum creatine kinase level, and time spent under the rubble), and EDx results were analyzed.
**Results:** Thirty-seven patients were included, while three patients with normal nerve conduction studies were excluded. Two (5.9%) of the 34 patients exhibited neurogenic and myogenic changes on EDx performed on days 24 and 25 post-trauma. In the remaining patients, neurogenic changes were observed, with 18 (52.9%) having peripheral nerve injury, 10 (29.4%) having plexopathy, 1 (2.9%) showing root involvement, and 5 (14.7%) of those with peripheral nerve injury presenting with complex involvement. Complete axonal damage was unrelated to the duration spent under the rubble (p=0.294). The presence of regeneration motor unit action potentials (MUAPs) was found statistically significantly related to the timing of the electromyography (EMG) performed (p=0.003), with the earliest regeneration findings observed on day 35. No statistically significant difference was found in the time spent under the rubble according to the regeneration presence (p=0.129).
**Conclusion:** This study shows that earthquake injuries primarily result in multiple peripheral nerve injuries. The regeneration MUAP occurrence was not related to the duration spent under the rubble. In addition, myogenic and neurogenic MUAPs may appear on EMG in neurogenic injuries caused by compartment syndrome.
**Keywords:** Earthquake; electromyography; myogenic; neurogenic; peripheral nerve injury.

**ÖZ**

**Amaç:** Bu çalışmanın amacı, Kahramanmaraş, Türkiye'de meydana gelen depremlerden etkilenen hastalarda nöromüsküler hasarın değerlendirmektir.
**Gereç ve Yöntemler:** Bu çalışmaya, Şubat ve Ağustos 2023 tarihleri arasında elektronöromiyografi (ENMG) laboratuvarına yönlendirilen ve enkaz altında kalmış olan hastalar dahil edilmiştir. Demografik veriler, klinik bilgiler (böbrek yetmezliği, serum kreatin kinaz düzeyi ve enkaz altında geçirilen süre) ve ENMG sonuçları analiz edilmiştir.
**Bulgular:** Otuz yedi hasta çalışmaya dahil edilirken, sinir iletim çalışmaları normal olan üç hasta çalışma dışı bırakıldı. Travma sonrası 24. ve 25. günlerde yapılan ENMG'de 34 hastanın ikisinde (%5,9) nörojenik ve miyojenik değişiklikler görüldü. Geri kalan hastalarda ise nörojenik değişiklikler gözlenmiş olup, 18 (%52,9)'inde periferik sinir hasarı, 10 (%29,4)'unda pleksopati, 1 (%2,9)'inde kök tutulumu ve periferik sinir hasarı olanların 5 (%14,7)'inde kompleks tutulum izlendi. Tam aksonal hasarın enkaz altında geçirilen süre ile ilişkisi bulunmadı (p=0,294). Rejenerasyon motor ünitesi aksiyon potansiyellerinin (MUAPs) varlığının yapılan elektromiyografi (EMG) zamanlaması ile istatistiksel olarak anlamlı ilişkili olduğu (p=0,003) ve en erken rejenerasyon bulgularının 35. günde gözlendiği bulundu. Rejenerasyon varlığına göre enkaz altında geçen sürede istatistiksel olarak anlamlı bir fark bulunmadı (p=0,129).
**Sonuç:** Bu çalışma, deprem yaralanmalarının öncelikle çoklu periferik sinir yaralanmalarına neden olduğunu göstermektedir. Rejenerasyon MUAP oluşumu enkaz altında geçirilen süre ile ilişkili değildir. Ek olarak, kompartıman sendromunun neden olduğu nörojenik yaralanmalarda EMG'de miyojenik ve nörojenik MUAP'lar görülebilir.
**Anahtar kelimeler:** Deprem; elektromiyografi; miyojenik; nörojenik; periferik sinir hasarı.

## INTRODUCTION

On February 6, 2023, two main earthquakes with magnitudes of 7.8 and 7.6, respectively, occurred nine hours apart in the Kahramanmaraş region of southeastern Turkey, according to the Kandilli Observatory and Earthquake Research Institute (1). Besides the two largest earthquakes, several other earthquakes with magnitudes between 4.0 and 6.6 occurred throughout the day. Too many people were trapped under the rubble. Crush syndrome, loss of extremities, or paralysis occurred due to the entrapment of limbs or other parts of the body.

The electrodiagnostic studies (EDx), which contain motor and sensory nerve conduction studies (NCSs) and needle electromyography (EMG) examination, are one of the important tools to diagnose nerve injury. In addition, it gives information about lesion localization, severity of nerve injury, and occurrence of regeneration according to the special time spaces (2). If the axonal loss or Wallerian degeneration has not occurred, the compound muscle action potential (CMAP) should be normal. The amplitude of the CMAP occurred by distal stimulation will start to fall approximately at day three and reach the lowest level approximately at day nine, and it will disappear by complete axon loss, however the actual time course depends on the length of the distal nerve segment between the lesion and the muscle (3). Wallerian degeneration in sensory fibers has occurred about 11 days post-injury, which is longer than motor NCSs due to the earlier failure of neuromuscular junction transmission (4). The spontaneous activity in EMG, which includes fibrillation potentials (FPs) and positive sharp waves (PSWs) are occurs according to the length between the injury and the distal nerve stump. If it is short, the FPs develop in only 10-14 days; if it is longer, 3-4 weeks are required for the development of FPs and PSWs (5). The motor unit action potentials (MUAPs) are not recorded in the complete axonal loss, while reduced or discrete recruitment with normal MUAPs morphology are recorded in the incomplete axonal loss at the beginning, and are followed by the increased percentage of polyphasy, prolonged duration, and increased amplitude of MUAPs (6). The regeneration occurs along the distal nerve segment at a rate of about 1 mm/day (7). The timing of EDx is decided by considering these pathophysiological and electrophysiological points. The studies reported that the peripheral nerve injuries are the most frequent damage due to an earthquake (8-10).

This study aimed to document findings of patients with nerve injury who were referred to EDx laboratories.

## MATERIAL AND METHODS

### Patients and Procedures

Ethics committee approval was obtained from the clinical research ethics committee of Başakşehir Çam and Sakura City Hospital (dated 24.05.2023, and numbered 200).

EDx findings were evaluated in patients who had been trapped under rubble following the earthquake and were referred between February and August 2023, with inclusion limited to those demonstrating pathological EDx results. Patients with a history of polyneuropathy, rheumatic disease, alcohol consumption, cervical and lumbar radiculopathy, hereditary pressure-sensitive neuropathy, myopathy, or any other traumatic sequelae were excluded from the study. Sensory and motor NCSs, along with concentric needle electrode (CNE) findings, were collected. Sensory NCSs were performed antidromically, and the peak-to-peak amplitude was considered. Sensory conduction velocity was evaluated based on baseline distal latency. Both extremities were evaluated, and the normal value was determined based on the contralateral extremity if it was unaffected. If both sides were affected, Shapiro's normal value was used as the reference (11). The EDx examination was performed by two different physicians (DMD, ŞD) using three distinct devices [Keypoint (Dantec, Denmark), Natus (Nicolet Viking Quest, Synergy), and Cadwell (Sierra Summit)] in the EMG laboratory of the Neurology Clinic at Başakşehir Çam and Sakura City Hospital.

The EDx protocols were determined based on the condition of the extremities. The EMG findings first evaluated the localization of nerve damage. Lesions were classified as root, plexus, or peripheral nerve injuries. Peripheral nerve damage was further classified as mononeuropathy or multiple peripheral neuropathy. The frequency of affected peripheral nerves was also noted.

The duration of time spent under the rubble, serum creatine kinase (CK) levels, history of renal failure, and presence of fasciotomy history were noted. Patients under the age of 18 years were considered a pediatric age group.

### Statistical Analysis

IBM SPSS version 26 was used for the statistical analysis. Descriptive statistics were conducted to examine the frequency distribution of nerve injuries. The Shapiro-Wilk test was used for normality assumption for age, time of EMG performed after trauma, time lying under rubble, and serum CK level. Due to the non-normal distribution, the median, interquartile range (IQR, Q3-Q1), and [min, max] were presented. The Mann-Whitney U test was used to compare numerical variables that did not show a normal distribution, while Fisher's exact test was used to analyze categorical data. Statistical significance was considered as a p-value of $<0.05$.

## RESULTS

Of the 2,170 patients affected by the earthquake who applied to the Başakşehir Çam and Sakura City Hospital, 37 (1.71%) were referred to the EDx laboratory. Three patients had normal NCSs and were excluded. Median age of the remaining 34 patients was 25 (range, 6-76) years. Eleven (32.4%) of the patients were in the pediatric age group, and 23 (67.6%) of the patients were in the adult age group (Table 1).

Regarding the localization of the damage, 52.9% (n=18) of patients had peripheral nerve injury, 29.4% (n=10) of patients had plexopathy, 2.9% (n=1) had root involvement, in addition to complex involvement of the peripheral nerve, plexus, and root in 14.7% (n=5). Peripheral nerve injuries were classified as mononeuropathy in 39.1% (n=9) and as multiple nerve injury in 60.9% (n=14). The most affected peripheral nerve was the fibular nerve (40.9%, n=9), followed by the tibial nerve (36.4%, n=8), ulnar nerve (27.3%, n=6), radial nerve (27.3%, n=6), and median nerve. (22.7%, n=5), sciatic nerve (18.2%, n=4), femoral nerve (4.5%, n=1), and musculocutaneous nerves (4.5%, n=1), respectively.

**Table 1.** Demographical and electromyographical results

| | n* | Median (Q1-Q3) [min-max] |
|---|---|---|
| **Age** (year) | 34 | 25 (15-43) [6-76] |
| **Time of EMG after trauma** (day) | 34 | 47 (25-70) [8-180] |
| **The time lying under rubble** (hour) | 32 | 22 (8-75) [4-144] |
| **Serum CK level** (IU/L) | 28 | 279.5 (36-432) [11-10215] |
| **Gender**, n (%) | | |
| Female | 34 | 20 (58.8) |
| Male | | 14 (41.2) |
| **Age group**, n (%) | | |
| Pediatric, <18 years | 34 | 11 (32.4) |
| Adult, >18 years | | 23 (67.6) |
| **Motor NCS**, n (%) | | |
| Partial | 34 | 14 (41.2) |
| No response | | 20 (58.8) |
| **Sensory NCS**, n (%) | | |
| Normal | | 1 (2.9) |
| Partial | 34 | 10 (29.4) |
| No response | | 23 (67.6) |
| **CNE-spontaneous**, n (%) | | |
| Normal | 33 | 1 (3.0) |
| Denervation potentials (PSW, FPs) | | 32 (97.0) |
| **CNE-denervation scale**, n (%) | | |
| 1+ | | 0 (0.0) |
| 2+ | 25 | 6 (24.0) |
| 3+ | | 19 (76.0) |
| **CNE-MUAPs**, n (%) | | |
| Neurogenic | 34 | 32 (94.1) |
| Myogenic and neurogenic | | 2 (5.9) |
| **With Regeneration**, n (%) | 29 | 17 (58.6) |
| **CNE-recruitment pattern**, n (%) | | |
| No activity | 32 | 28 (84.8) |
| Decreased | | 4 (12.2) |
| **Distribution of nerve damage**, n (%) | | |
| Upper Extremity | 34 | 11 (32.4) |
| Lower Extremity | | 23 (67.6) |
| **Fasciotomy**, n (%) | 34 | 22 (64.7) |
| **Kidney Failure**, n (%) | 24 | 8 (33.3) |

*: number of patients the statistics were calculated, Q1-Q3: 25th-75th percentile, EMG: electromyography, CK: creatine kinase, NCS: nerve conduction studies, CNE: concentric needle electrode, PSW: positive sharp waves, FPs: fibrillation potentials, MUAPs: motor unit action potentials

Two (5.9%) of 34 exhibited neurogenic and myogenic changes in EMG that was performed on days 24 and 25 of trauma. These two patients also had acute kidney failure and elevated CK levels, which are 23000 and 111000 IU/L, respectively. Myogenic changes were found in only two patients with a history of renal failure. However, renal failure was not statistically significantly related to either myogenic MUAPs (100% vs 0.0%, p=0.101) or elevated CK levels (21.5 vs 13.96, p=0.212). Additionally, myogenic MUAPs were not statistically significantly related to a history of fasciotomy (0.0% vs 100%, p=0.212).

The results of motor and sensory NCVs and EMG findings, as well as whether fasciotomy was performed and whether kidney dysfunction was present, were summarized in Table 1.

Distal total axonal damage was more prominent in the lower extremities (75.0% vs 25.0%, p=0.033) compared to the upper extremities. Complete axonal injury was not statistically significantly related to the duration of time spent under the rubble (12.10 vs 16.75, p=0.294).

The presence of regeneration MUAPs was related to the timing of EDx performed (18.94 vs 9.42, p=0.003). The earliest day for the presence of regeneration was day 35. Presence of regeneration MUAPs was not differed to the duration time of underlying the rubble, localization of the damage in upper or lower extremities, presence of renal failure, and severity of axonal damage (16.07 vs 11.42, p=0.129; 77.8 vs 50.0%, p=0.234; 25.0% vs 75.0%, p=0.133; 100% vs 52.0%, p=0.121, respectively).

The pediatric and adult age groups did not differ in terms of damage to the upper or lower extremities. Although regeneration of MUAPs was higher in the pediatric group compared to the adult group, this difference was not statistically significant (87.5% vs. 47.6%, p=0.060).

## DISCUSSION

The results of the study demonstrated early post-earthquake neuromuscular damage. We primarily found neurogenic changes due to peripheral nerve damage on EDx in earthquake survivors. Complete axonal degeneration was more prominent in the lower extremities compared to the upper extremities, and the most affected nerve was the fibular nerve. The fibular nerve may be more prone to damage than other nerves due to its anatomical pathway. On the other hand, one patient had demyelination of the ulnar nerve at the elbow, possibly due to an inability to protect the extremity's position. According to the latest studies on nerve injury resulting from earthquakes, peripheral nerve injury is the most frequent type of damage, which confirms the study results (8-10).

The regeneration MUAPs were recorded in 17 (58.6%) patients, and was observed on day 35, which is the earliest time in the study group. The severity of axonal damage, the presence of kidney comorbidities, and the time spent under the rubble did not relate to the presence of regeneration MUAPs. The timing of regeneration depends on nerve length, with regeneration speed known to be approximately 1 mm/day, and the earliest time is 30 days for evaluating regeneration MUAPs, which is supported by our results. The significance of regenerative MUAPs lies in predicting that clinical improvement may begin earlier than 2-3 months (12). Regeneration was observed at a higher percentage in the pediatric age group compared to the adult group (87.5% vs. 47.6%, respectively). However, this difference was not statistically significant. These results are similar to those reported after the Marmara Earthquake (8). In the present study, only 9% of the pediatric age group was referred for EDx laboratories before the 35th day post-trauma, whereas 39% of the adult age group was referred within the same period. The higher percentage of regeneration in the pediatric group may be related to the later referral of pediatric patients, as physicians may avoid performing EMG on younger patients compared to adults. Another reason may be the shorter nerve length in pediatric patients compared to adult patients.

Two patients in this study had concomitant myogenic and neurogenic changes. Other studies have not mentioned myogenic changes in earthquake survivors. EMG examinations were performed on the 24th-25th days after being trapped, which is early for observing regenerative MUAPs in the two patients who exhibited myogenic

changes. The myogenic changes may be due to muscle fiber damage or necrosis caused by insufficient blood supply as a result of high compartmental pressure (13,14). The extremities of these two patients were enlarged, with thin, tense, and swollen skin; unfortunately, we did not have the opportunity to measure the pressure in the affected compartments. These two patients had spent eight hours under the rubble, exhibited high CK levels, and required hemodialysis due to rhabdomyolysis. Although other patients whose EMG findings showed only neurogenic changes had a history of fasciotomy, these two patients with myogenic changes did not require fasciotomy during their follow-up. Although it is difficult to draw definitive conclusions from these two cases alone, we speculate that the presence of both myogenic and neurogenic changes does not necessarily indicate a need for fasciotomy or a poor prognosis for all patients.

The study has several limitations. Firstly, we included all patients referred to the EDx laboratory, but some data were missing due to the retrospective analysis. Secondly, our case series was relatively small. Thirdly, some muscles could not be evaluated due to the extensive damage in those areas. Another limitation is that follow-up EMG could not be performed because most patients moved to other cities after their treatment.

## CONCLUSION

The present study demonstrates that peripheral nerve injury is the most common cause of axonal degeneration following earthquake trauma. Another result is that both myogenic and neurogenic MUAP changes can occur in patients with neuronal damage who experience rhabdomyolysis. Furthermore, regeneration MUAPs can develop regardless of the duration spent under the rubble.

**Ethics Committee Approval:** The study was approved by the clinical research ethics committee of the Başakşehir Çam and Sakura City Hospital (24.05.2023, 200).

**Conflict of Interest:** None declared by the authors.

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## REFERENCES

1. Hussain E, Kalaycıoğlu S, Milliner CWD, Çakır Z. Preconditioning the 2023 Kahramanmaraş (Türkiye) earthquake disaster. Nat Rev Earth Environ. 2023;4(5):287-9.
2. Robinson LR. Traumatic injury to peripheral nerves. Muscle Nerve. 2022;66(6):661-70.
3. Chaudhry V, Cornblath DR. Wallerian degeneration in human nerves: serial electrophysiological studies. Muscle Nerve. 1992;15(6): 687-93.
4. Ferrante MA. The assessment and management of peripheral nerve trauma. Curr Treat Options Neurol. 2018;20(7):25.
5. Thesleff S. Trophic functions of the neuron. II. Denervation and regulation of muscle. Physiological effects of denervation of muscle. Ann N Y Acad Sci. 1974;228(0):89-104.
6. Dorfman LJ. Quantitative clinical electrophysiology in the evaluation of nerve injury and regeneration. Muscle Nerve. 1990;13(9):822-8.
7. Sunderland S. The anatomy and physiology of nerve injury. Muscle Nerve. 1990;13(9):771-84.
8. Uzun N, Savrun FK, Kiziltan ME. Electrophysiologic evaluation of peripheral nerve injuries in children following the Marmara earthquake. J Child Neurol. 2005;20(3):207-12.
9. Uzun N, Tanriverdi T, Savrun FK, Kiziltan ME, Sahin R, Hanimoglu H, et al. Traumatic peripheral nerve injuries: demographic and electrophysiologic findings of 802 patients from a developing country. J Clin Neuromuscul Dis. 2006;7(3):97-103.
10. Gesoglu Demir T, Ethemoplu KB. Clinical, etiological, and electrophysiological characteristics of patients with peripheral nerve damage caused by the February 6 earthquake in Türkiye. Turk J Neurol. 2024;30(3):141-8.
11. Preston DC, Shapiro BE. Electromyography and neuromuscular disorders. 4th ed. Appendix: nerve conduction studies: normal adult values, pediatric values. Amsterdam: Elsevier; 2020. p.763.
12. Oh SJ. Electromyographic studies in peripheral nerve injuries. South Med J. 1976;69(2):177-82.
13. Myers RR, Mizisin AP, Powell HC, Lampert PW. Reduced nerve blood flow in hexachlorophene neuropathy: relationship to elevated endoneurial fluid pressure. J Neuropathol Exp Neurol. 1982;41(4):391-9.
14. Broadhurst PK, Robinson LR. Compartment syndrome: Neuromuscular complications and electrodiagnosis. Muscle Nerve. 2020;62(3):300-8.