Electrodiagnostic Evaluation of Prognostic Factors Influencing the Surgical Outcomes of Upper Extremity Nerve Injuries Caused by Penetrating Trauma: A Cross-sectional Study

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ABSTRACT

Background: Peripheral nerve damage is a major cause of disability, which can lead to serious limitations in daily and occupational activities. Although primary repair can restore the function of the damaged organ remarkably, factors predicting the prognosis of nerve repair are a topic of constant debate. We aimed to investigate the factors affecting the outcomes of primary nerve repair in patients afflicted by upper extremity nerve injuries following penetrating trauma.

Methods: This cross-sectional study was conducted on 51 patients referred to Shohada-ye Ashayer Hospital in Khorramabad, Iran, from 2016 to 2021. Data including the patient's age, gender, education, type, severity, and mechanism of injury, the damaged nerve, time and of method repair, the surgeon's specialty, as well as the electrodiagnostic findings, were collected and analyzed using SPSS software version 22.

Results: The mean age of the patients was 30.41 ± 12.63 years, and the majority of them (84.3%) were men. A significant relationship was found between the sensory amplitude with education (P=0.002), the type of damaged nerve (P=0.048), and the severity of injury (P=0.012). The positive sharp wave was significantly associated with the surgeon's specialty (P=0.034). Besides, the motor amplitude was considerably related to the patient's age (P=0.040) and the surgeon's specialty (P=0.035).

Conclusion: Factors determining the outcome of peripheral nerve repair following penetrating trauma to the upper extremity include age, education, the type of damaged nerve, the severity of the injury, and the surgeon's specialty.

KEYWORDS

Peripheral nerve; Upper extremity; Electrodiagnosis; Penetrating trauma

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INTRODUCTION

Peripheral nerve injuries are a common neurosurgical condition that can attenuate motor and sensory functions, resulting in physical disability ¹. About 20 million Americans are afflicted by peripheral nerve injuries each year, resulting in an annual cost of 150 billion dollars ^{2, 3}. Peripheral nerve injuries can be caused by different mechanisms such as trauma and iatrogenic interventions. However, most cases of nerve damage in the upper limbs are caused by trauma ^{1, 4}. These injuries occur mostly in young active individuals and diminish their quality of life ^{1, 5}. The impaired nerve fibers can regenerate spontaneously, however, this ability is limited by the size of the nerve defect, as well as the formation of neuroma and scar, denoting the importance of early nerve reconstruction^{6,7}.

The reconstruction of impaired peripheral nerves is critical for the achievement of a decent regeneration. Nevertheless, recovery from the injuries is usually dissatisfying. Besides the complications of reconstruction, ambiguity in the prognostic factors is a substantial challenge. Early surgical intervention in affected individuals based on their profile of prognostic factors can ameliorate the outcomes of peripheral nerve injury ⁸. Some modifiable and unmodifiable factors such as age, gender, educational level, type of damaged nerve, and site of the injury have been attributed to the success rate of nerve repair ^{8, 9}. However, the outcomes of nerve reconstruction have been seldom examined using valid and reliable tools ¹⁰.

Electrodiagnostic studies, including electromyography (EMG) and nerve conduction velocity (NCV), are considered the gold standard for detecting nerve injuries and predicting the outcomes of their reconstruction ¹¹. Given the infrequent use of valid and reliable tools to determine the factors affecting the outcomes of primary nerve repair in previous studies, we aimed to design to examine the prognostic factors for the outcomes of primary nerve repair in patients afflicted by upper extremity nerve injuries following penetrating trauma.

METHOD AND MATERIALS

Study design and participants

This was a descriptive cross-sectional study conducted at the Shohada-ye Ashayer Hospital

in Khorramabad, Iran, from 2016 to 2021. The inclusion criteria were undergoing primary nerve repair following upper extremity nerve injuries caused by penetrating trauma. The patients were excluded if their medical files were incomplete. The sampling method was census and 51 patients who met the inclusion criteria were included.

Data collection

After obtaining written and informed consent, data including the patient's age, gender, educational level, type, severity, and mechanism of injury, type of damaged nerve, time and of method repair, and the surgeon's specialty were collected from the patient's medical files. All patients were examined using EMG and NCV tests by the same neurologist. Then, the findings were registered into a researcher-made checklist.

Data analysis

The collected data were analyzed using SPSS software version 22 (IBM Corp., Armonk, NY, USA). Descriptive statistics tools including contingency tables, frequency, and percentage as well as mean and standard deviation and were used to describe the data. Furthermore, the Chi-square test was used to examine the relationship between categorical variables. The significance level was considered <0.05 for all statistical tests.

Ethical considerations

This study was approved by the Research Ethics committee of Lorestan University of Medical Sciences with the ethical IR.LUMS.REC.1399.381. Written informed consent was obtained from all participants in this study. The checklists were designed anonymously and patients' personal information was kept confidential.

RESULTS

Fifty-one patients with upper limb nerve injuries due to penetrating trauma were studied. The mean age of the patients was 30.41 ± 12.63 with a minimum age of 11 and a maximum of 68 years. Other demographic characteristics are shown in Table 1.

The frequency distribution of EMG/NCV findings in patients is shown in Table 2. Motor amplitude was normal in 11 patients, while showed a \leq 50%

	Variable	Frequency	Percentage
Condon	Female	8	15.7
Gender	Male	43	84.3
	≤30	29	56.9
Age (years)	30<	22	43.1
··· · · · ·	Yes	6	11.8
Underlying diseases	No	45	88.2
	Lower than a high school diploma	31	60.8
Educational level	High school diploma	15	29.4
	College or university degree	5	9.8
Place of residence	Urban	41	80.4
	Rural	10	19.6

Table 1: Frequency distribution of demographic variables in patients with the upper limb nerve injury

Table 2: Frequency distribution of EMG/NCV findings in patients with the upper limb nerve injury

Varia	Variable		Percentage
	Normal	11	21.6
Motor omglitudo	≤50% decrease	Frequency Percentage nal 11 21.6 crease 7 13.7 crease 8 15.7 ne 25 49.0 nal 7 13.7 ased 5 9.8 ne 39 76.5 22 43.1 5 s 29 56.9 26 51.0 5 s 25 49.0	13.7
Motor amplitude	50%< decrease	8	15.7
	None	25	49.0
	Normal	7	13.7
Sensory amplitude	Decreased	Frequency P 11 11 ase 7 25 7 7 11 39 22 29 26 25 25	9.8
	Variable Normal Image: Second	39	76.5
Desitive sharp wave	No	22	43.1
Positive sharp wave	Yes	29	56.9
D 1 1 1	No	26	51.0
Polyphasic wave	Yes	25	49.0

decrease in 7, and a 50%< decrease in 8 subjects. Sensory amplitude was normal in 7 patients and reduced in 5 patients.

As shown in Table 3, the frequency of patients with no motor amplitude was higher in those aged >30 years (n=13; 59.1%) The statistical analysis showed a significant relationship between motor amplitude and age (P=0.040). Besides, there was a significant association between motor amplitude and surgeon's specialty (P=0.035). As the patients operated by plastic surgeons had the highest frequency of normal motor amplitude (n=10; 34.5%).

However, there was no significant relationship between motor amplitude with gender (P=0.845), place of residence (P=0.347), educational level (P=0.604), damaged organ (P=0.111), the severity of nerve damage (P=0.295), mechanism of injury (P=0.727), damaged nerve (P=0.561), duration between injury and repair (P=0.357), and duration between repair and electrodiagnostic studies (P=0.097).

As shown in Table 4, three patients (7.1%) with complete nerve injury had normal sensory amplitude while four patients (44.4%) with partial injury showed normal amplitude. The analysis revealed a significant relationship between the severity of nerve damage (P=0.012). There was also a remarkable relationship between sensory amplitude and damaged nerve (P=0.048). As eleven patients with ulnar injuries (91.7%) showed no sensory amplitude. Patients with an educational level lower than a high school diploma had the lowest rate of normal sensory amplitude (n=2; 6.5%), and there was a significant relationship between sensory amplitude and educational level (P=0.002). However, there was no significant relationship

between sensory amplitude with gender (P=0.232), place of residence (P=0.813), damaged organ

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(P=0.679), mechanism of injury (P=0.199), age (P=0.886), duration between injury and repair (P=0.348), duration between repair and electrodiagnostic studies (P=0.870), and surgeon's specialty (P=0.400).

As shown in Table 5, there was a significant relationship between positive sharp waves with damaged organs (P=0.007). Arm and Forearm injuries were associated with the highest frequency of positive sharp waves. (n=1; 100% and n=12;

		Motor amplitude					
	Variable		N	≤50%	50%<	News	P-value
			Normai	decrease	decrease	None	
	Mala	Frequency	9	6	6	22	
Condor	Male	Percentage	20.9	14.0	14.0	51.2	0.845
Genuer	Famala	Frequency	2	1	2	3	
	Tennale	Percentage	25.0	12.5	25.0	37.5	
Place of residence	Urban	Frequency	9	5	5	22	0.347
		Percentage	22.0	12.2	12.2	53.7	
	Rural	Frequency	2	2	3	3	
	Itter	Percentage	20.0	20.0	30.0	30.0	
	College or	Frequency	2	1	0	2	_
	university degree	Percentage	40.0	20.0	.0	40.0	
Educational level	High school	Frequency	1	2	3	9	0 604
	diploma	Percentage	6.7	13.3	20.0	60.0	0.001
	Lower than a high	Frequency	8	4	5	14	-
	school diploma	Percentage	25.8	12.9	16.1	45.2	
Damaged organ	Wrist	Frequency	9	5	7	11	0.111
	VV 115t	Percentage	28.1	15.6	21.9	34.4	
	Forearm	Frequency	2	1	0	11	
		Percentage	14.3	7.1	.0	78.6	
	Elbow	Frequency	0	0	0	1	
Dunnagen örgun		Percentage	.0	.0	.0	100.0	
	Arm	Frequency	0	1	0	0	
		Percentage	.0	100.0	.0	.0	
	Shoulder	Frequency	0	0	1	2	
	onouruor	Percentage	.0	.0	33.3	66.7	
	Complete	Frequency	7	5	7	23	
Severity of nerve	P	Percentage	16.7	11.9	16.7	54.8	0.295
damage	Partial	Frequency	4	2	1	2	0.275
		Percentage	44.4	22.2	11.1	22.2	
	Cut	Frequency	9	7	7	23	-
Mechanism of		Percentage	19.6	15.2	15.2	50.0	0.727
injury	Crushing	Frequency	2	0	1	2	0.727
	Orushing	Percentage	40.0	.0	20.0	40.0	
	D . 1. 1	Frequency	4	2	0	6	
	Kadial	Percentage	33.3	16.7	.0	50.0	
The damaged nerve		Frequency	5	4	5	13	0.5(1
	Median	Percentage	18.5	14.8	18.5	48.1	0.561
		Frequency	2	1	3	6	1
	Ulnar	Percentage	16.7	8.3	25.0	50.0	1
		Frequency	5	7	5	12	
	≤30	Percentage	17.2	24.1	17.2	41.4	
Age (years)		Frequency	6	0	3	13	0.040
	30<	Percentage	27.3	.0	13.6	59.1	-

Table 3: Relationship between motor amplitude and patient's characteristics

		Motor amplitude					
	Variable		N1	≤50%	50%<	News	P-value
			Normai	decrease	decrease	None	
	1	Frequency	8	4	4	8	-
	1	Percentage	33.3	16.7	16.7	33.3	
Dunation	2	Frequency	1	0	1	2	
Duration	2	Percentage	25.0	.0	25.0	50.0	0.257
between injury	2	Frequency	2	2	1	6	0.557
and repair (days)	3	Percentage	18.2	18.2	9.1	54.5	_
	4≤	Frequency	0	1	2	9	
		Percentage	.0	8.3	16.7	75.0	
Duration	≥2	Frequency	1	0	0	0	0.097
batwaan sonais		Percentage	100.0	.0	.0	.0	
ord	2-4	Frequency	5	0	2	6	
allu alaatuu dia an aatia		Percentage	38.5	.0	15.4	46.2	
electrodiagnostic	>4	Frequency	5	7	6	19	
studies (months)	24	Percentage	13.5	18.9	16.2	51.4	
	Conoral	Frequency	0	1	3	7	
Surgeon's specialty	General	Percentage	.0	9.1	27.3	63.6	
	Dlastic	Frequency	10	5	5	9	0.035
	Plastic	Percentage	34.5	17.2	17.2	31.0	0.035
	Outhonodics	Frequency	1	1	0	9	
	Orthopedics	Percentage	9.1	9.1	.0	81.8	

85.7%, respectively). Moreover, patients operated by plastic surgeons showed the lowest frequency of positive sharp waves (n=12; 41.4%). The statistical analysis demonstrated a significant relationship between positive sharp waves and the surgeon's specialty (P=0.034).

However, there was no significant relationship between positive sharp waves with gender (P=0.713), place of residence (P=0.556), educational level (P=0.544), the severity of nerve damage (P=0.150), mechanism of injury (P=0.641), damaged nerve (P=0.559), age (P=0.503), duration between injury and repair (P=0.516), and duration between repair and electrodiagnostic studies (P=0.727).

As shown in Table 6, patients with forearm injury had the lowest frequency of polyphasic waves (n=3;21.4%). There was a significant relationship between polyphasic waves with damaged organs (*P*=0.014).

However, there was no significant relationship between polyphasic waves with gender (P=0.626), place of residence (P=0.725), educational level (P=0.836), the severity of nerve damage (P=0.075), mechanism of injury (P=0.668), damaged nerve (P=0.404), age (P=0.779), duration between injury and repair (P=0.710), duration between repair and electrodiagnostic studies (*P*=0.523), and surgeon's specialty (*P*=0.091).

DISCUSSION

We investigated the factors affecting the outcomes of primary nerve repair in 51 patients afflicted by upper extremity nerve injuries following penetrating trauma. Prognostic factors of the outcomes of nerve repair following penetrating trauma to the upper extremity included age, education, the type of damaged nerve, the severity of the injury, and the surgeon's specialty. In our study, most of the patients aged ≤30 years. Previous studies have widely demonstrated the highest proportion of peripheral nerve injuries in young people, especially in the age group of 20 to 30 years, who comprise the most active members of societies ¹²⁻¹⁴. In the studied population, the frequency of men was about 5 times that of women. The male predominance among patients afflicted by peripheral nerve injuries is widely reported in the literature ^{15, 16}. In most societies, men are more involved in occupational activities compared to women. In addition, most of the victims of accidents are reported to be young men, which leads to an increased risk of trauma and

subsequent nerve injury ¹⁷. However, except for an association between older age and higher frequency of lack of motor amplitude, the present study showed no significant relationship between electrodiagnostic findings with gender and age. Where physical

examination and questionnaires have been used to evaluate postoperative neurological function, women and younger individuals have shown a better recovery from peripheral nerve injuries ⁸. However, few studies that have utilized electrodiagnostic tests

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$\begin{tabular}{ c c c c } \hline School diploma & Percentage & 6.5 & 6.5 & 87.1 \\ \hline Frequency & 5 & 2 & 25 & Percentage & 15.6 & 6.3 & 78.1 & Percentage & 14.3 & 21.4 & 64.3 & Percentage & 14.3 & 21.4 & 64.3 & Percentage & 0 & 0 & 1 & Percentage & 0 & 0 & 1 & Percentage & 0 & 0 & 100.0 & Percentage & 0 & 0 & 0 & 100.0 & Percentage & 0 & 0 & 0 & 100.0 & Percentage & 0 & 0 & 0 & 100.0 & Percentage & 0 & 0 & 0 & 100.0 & Percentage & 0 & 0 & 0 & 100.0 & Percentage & 0 & 0 & 0 & 100.0 & Percentage & 0 & 0 & 0 & 100.0 & Percentage & 0 & 0 & 0 & 100.0 & Percentage & 0 & 0 & 0 & 100.0 & Percentage & 0 & 0 & 0 & 100.0 & Percentage & 0 & 0 & 0 & 100.0 & Percentage & 0 & 0 & 0 & 100.0 & Percentage & 0 & 0 & 0 & 100.0 & Percentage & 0 & 0 & 0 & 100.0 & Percentage & 0 & 0 & 0 & 100.0 & Percentage & 0 & 0 & 0 & 100.0 & Percentage & 0 & 0 & 0 & 100.0 & Percentage & 7.1 & 11.9 & 81.0 & 0.012 & Percentage & 7.1 & 11.9 & 81.0 & 0.012 & Percentage & 10.9 & 10.9 & 78.3 & 0.199 & Percentage & 10.9 & 10.9 & 78.3 & 0.199 & Percentage & 10.9 & 10.9 & 78.3 & 0.199 & Percentage & 10.9 & 10.9 & 78.3 & 0.199 & Percentage & 40.0 & 0 & 0 & 66.7 & Percentage & 40.0 & 0 & 66.7 & Percentage & 33.3 & 0 & 66.7 & Percenta$		Lower than a high	Frequency	2	2	27	
$\begin{tabular}{ c c c c } \hline $Frequency & 5 & 2 & 25 \\ \hline $Percentage & 15.6 & 6.3 & 78.1 \\ \hline $Percentage & 14.3 & 21.4 & 64.3 \\ \hline $Percentage & 14.3 & 21.4 & 64.3 \\ \hline $Percentage & 14.3 & 21.4 & 64.3 \\ \hline $Percentage & 14.3 & 21.4 & 64.3 \\ \hline $Percentage & 14.3 & 21.4 & 64.3 \\ \hline $Percentage & 10.0 & 0 & 1 \\ \hline $Percentage & 0.0 & 0 & 1 \\ \hline $Percentage & 0.0 & 0 & 100.0 \\ \hline $Percentage & 0.0 & 0 & 100.0 \\ \hline $Percentage & 0.0 & 0 & 100.0 \\ \hline $Percentage & 0.0 & 0 & 100.0 \\ \hline $Percentage & 0.0 & 0 & 100.0 \\ \hline $Percentage & 0.0 & 0 & 100.0 \\ \hline $Percentage & 0.0 & 0 & 100.0 \\ \hline $Percentage & 0.0 & 0 & 100.0 \\ \hline $Percentage & 0.0 & 0 & 100.0 \\ \hline $Percentage & 7.1 & 11.9 & 81.0 \\ \hline $Percentage & 7.1 & 11.9 & 81.0 \\ \hline $Percentage & 7.1 & 11.9 & 81.0 \\ \hline $Percentage & 10.9 & 10.9 & 78.3 \\ \hline $Percentage & 10.9 & 10.9 & 78.3 \\ \hline $Percentage & 10.9 & 10.9 & 78.3 \\ \hline $Percentage & 10.9 & 10.9 & 78.3 \\ \hline $Percentage & 40.0 & 0 & 60.0 \\ \hline $Percentage & 40.0 & 0 & 60.0 \\ \hline $Percentage & 10.9 & 10.9 & 78.3 \\ \hline $Percentage & 33.3 & 0.0 & 66.7 \\ \hline $Percentage & 33.3 & 0.0 & 66.7 \\ \hline $Percentage & 33.3 & 0.0 & 66.7 \\ \hline $Percentage & 7.4 & 18.5 & 74.1 \\ \hline $Percentage & 7.4 & 18.5 & 74.1 \\ \hline $Percentage & 7.4 & 18.5 & 74.1 \\ \hline $Percentage & 7.4 & 18.5 & 74.1 \\ \hline $Percentage & 8.3 & 0 & 91.7 \\ \hline $Percentage & 8.3 & 0 & 91.7 \\ \hline $Percentage & 8.3 & 0 & 91.7 \\ \hline $Percentage & 8.3 & 0 & 91.7 \\ \hline $Percentage & 8.3 & 0 & 91.7 \\ \hline $Percentage & 10.3 & 10.3 & 79.3 \\ \hline $Percentage & 10.3 & 10.3 & 79.3 \\ \hline $Percentage & 10.3 & 10.3 & 79.3 \\ \hline $Percentage & 10.3 & 10.3 & 79.3 \\ \hline $Percentage & 10.3 & 10.3 & 79.3 \\ \hline $Percentage & 10.3 & 10.3 & 79.3 \\ \hline $Percentage & 10.3 & 10.3 & 79.3 \\ \hline $Percentage & 10.3 & 10.3 & 79.3 \\ \hline $Percentage & 10.3 & 10.3 & 79.3 \\ \hline $Percentage & 10.3 & 10.3 & 79.3 \\ \hline $Percentage & 10.3 & 10.3 & 79.3 \\ \hline $Percentage & 10.3 & 10.3 & 79.3 \\ \hline $Percentage & 10.3 & 10.3 & 79.3 \\ \hline $Percentage & 10.3 & 10.3 & 79.3 \\ \hline $Percentage & 10.3 & 10.3 & 79.3 \\ \hline $Percentage & 10.3 & 10.3 & 79.3 \\ \hline $Percentage & 10.3 & 10.3 & 7$		school diploma	Percentage	6.5	6.5	87.1	
$\begin{tabular}{ c c c } \hline Parcentage 15.6 6.3 78.1 0.63 78.1 0.63 78.1 0.67 0.6$			Frequency	5	2	25	
$\begin{tabular}{ c c c } \hline Percentage & I & I & I & I & I & I & I & I & I & $		W rist	Percentage	15.6	6.3	78.1	
$\begin{split} \begin{tabular}{ c c c } \hline Percentage & 14.3 & 21.4 & 64.3 \\ \hline Percentage & 0 & 0 & 1 \\ \hline Percentage & 0 & 0 & 1 \\ \hline Percentage & 0 & 0 & 1 \\ \hline Percentage & 0 & 0 & 1 \\ \hline Percentage & 0 & 0 & 1 \\ \hline Percentage & 0 & 0 & 1 \\ \hline Percentage & 0 & 0 & 1 \\ \hline Percentage & 0 & 0 & 3 \\ \hline Percentage & 0 & 0 & 1 \\ \hline Percentage & 0 & 0 & 3 \\ \hline Percentage & 0 & 0 & 1 \\ \hline Percentage & 0 & 0 & 3 \\ \hline Percentage & 0 & 0 & 1 \\ \hline Percentage & 0 & 0 & 1 \\ \hline Percentage & 0 & 0 & 1 \\ \hline Percentage & 0 & 0 & 1 \\ \hline Percentage & 0 & 0 & 1 \\ \hline Percentage & 0 & 0 & 1 \\ \hline Percentage & 7.1 & 11.9 & 81.0 \\ \hline Percentage & 7.1 & 11.9 & 81.0 \\ \hline Percentage & 44.4 & 0 & 55.6 \\ \hline Percentage & 10.9 & 10.9 & 78.3 \\ \hline Percentage & 10.9 & 10.9 & 78.3 \\ \hline Percentage & 10.9 & 10.9 & 78.3 \\ \hline Percentage & 10.9 & 10.9 & 78.3 \\ \hline Percentage & 33.3 & 0 & 66.7 \\ \hline Percentage & 33.3 & 0 & 66.7 \\ \hline Percentage & 33.3 & 0 & 66.7 \\ \hline Percentage & 33.3 & 0 & 66.7 \\ \hline Percentage & 33.3 & 0 & 66.7 \\ \hline Percentage & 33.3 & 0 & 66.7 \\ \hline Percentage & 33.3 & 0 & 66.7 \\ \hline Percentage & 33.3 & 0 & 66.7 \\ \hline Percentage & 33.3 & 0 & 66.7 \\ \hline Percentage & 33.3 & 0 & 66.7 \\ \hline Percentage & 33.3 & 0 & 66.7 \\ \hline Percentage & 33.3 & 0 & 66.7 \\ \hline Percentage & 33.3 & 0 & 66.7 \\ \hline Percentage & 33.3 & 0 & 66.7 \\ \hline Percentage & 33.3 & 0 & 66.7 \\ \hline Percentage & 7.4 & 18.5 & 74.1 \\ \hline Percentage & 7.4 & 18.5 & 74.1 \\ \hline Percentage & 8.3 & 0 & 91.7 \\ \hline \hline Percentage & 8.3 & 0 & 91.7 \\ \hline \hline Percentage & 8.3 & 0 & 91.7 \\ \hline \hline Percentage & 8.3 & 0 & 91.7 \\ \hline \hline \hline Percentage & 10.3 & 10.3 & 79.3 \\ \hline \hline Percentage & 10.3 & 10.3 & 79.3 \\ \hline \hline Percentage & 10.3 & 10.3 & 79.3 \\ \hline \hline \hline Percentage & 10.3 & 10.3 & 79.3 \\ \hline \hline \hline \hline Percentage & 10.3 & 10.3 & 79.3 \\ \hline \hline \hline \hline \hline Percentage & 10.3 & 10.3 & 79.3 \\ \hline $		- F	Frequency	2	3	9	
$\begin{split} \begin{tabular}{ c c c c } \hline $ $ $ $ $ $ $ $ $ $ $ $ $ $ $ $ $ $ $		Forearm	Percentage	14.3	21.4	64.3	0.679
$\begin{tabular}{ c c c c } \hline \begin{tabular}{ c c c c c } \hline \begin{tabular}{ c c c c c c } \hline \begin{tabular}{ c c c c c c } \hline \begin{tabular}{ c c c c c c c } \hline \begin{tabular}{ c c c c c c c } \hline \begin{tabular}{ c c c c c c c } \hline \begin{tabular}{ c c c c c c c c c c c c c c c c c c c$	D 1	Elbow	Frequency	0	0	1	
$\begin{split} \end{figure} & \begin{tabular}{ c c c } \hline $ $ $ $ $ $ $ $ $ $ $ $ $ $ $ $ $ $ $	Damaged organ		Percentage	.0	.0	100.0	
Arm Percentage .0 .0 100.0 $Boulder$ Frequency 0 0 3 $Boulder$ Percentage .0 .0 100.0 $Boulder$ Percentage .0 .0 100.0 $Boulder$ Percentage .0 .0 100.0 $Boulder$ Frequency 3 5 34 $Percentage$ 7.1 11.9 81.0 .012 $Amage$ Partial Frequency 4 0 55.6 $Mechanism of injury$ $Frequency$ 5 5 36 $Percentage$ 10.9 10.9 78.3 .199 $Mechanism of injury$ $Frequency$ 2 0 3 .199 $Frequency 4 0 8 .199 .199 .199 Mechanism of injury Frequency 4 0 8 .199 .199 Frequency 4 0 8 .199 .199 $		Arm Shoulder	Frequency	0	0	1	
$\begin{tabular}{ c c c c } \hline $ $ $ $ $ $ $ $ $ $ $ $ $ $ $ $ $ $ $			Percentage	.0	.0	100.0	
Shoulder Percentage .0 .00 100.0 Severity of nerve damage Complete Frequency 3 5 34 Partial Percentage 7.1 11.9 81.0 .012 Mechanism of injury Frequency 4 0 5 .012 Mechanism of injury Frequency 5 5 36 .019 Mechanism of injury Frequency 5 5 36 .0199 Mechanism of injury Frequency 2 0 3 .0199 Mechanism of injury Frequency 4 0 8 .0199 Mechanism of injury Frequency 2 0 3 .0199 Mechanism of injury Frequency 4 0 8 .0199 Mechanism of injury Frequency 1 0 1 .0199 Mechanism of injury Frequency 2 5 20 .0199 Median Frequency 1 0 <			Frequency	0	0	3	
Severity of nerve damage Complete Frequency 3 5 34 \best{here} he			Percentage	.0	.0	100.0	
Severity of nerve damage Complete Percentage 7.1 11.9 81.0 0.012 Mathematication Partial Frequency 4 0 5 0.012 Mechanism of injury Cut Frequency 5 5 36 0.019 Mechanism of injury Crushing Frequency 5 5 36 0.019 Mechanism of injury Crushing Frequency 2 0 3 0.019 Mechanism of injury Radial Frequency 2 0 3 0.019 The damaged nerve Radial Frequency 4 0 8 0.019 Median Frequency 4 0 8 0.048 0.048 Percentage 33.3 .0 66.7 0.048 0.048 0.048 Percentage 7.4 18.5 74.1 0.048 0.048 0.048 0.048 0.048 0.048 0.048 0.048 0.048 0.048 0.048			Frequency	3	5	34	
$\begin{array}{c c c c c c c } \mbox{damage} & Partial & Frequency & 4 & 0 & 5 & 0.012 \\ \hline Percentage & 44.4 & 0.0 & 55.6 & 0.012 \\ \hline Percentage & 44.4 & 0.0 & 55.6 & 0.012 & 0.$	Severity of nerve	Complete	Percentage	7.1	11.9	81.0	
Partial Percentage 44.4 .0 55.6 Mechanism of injury Cut Frequency 5 5 36 Mechanism of injury Crushing Frequency 2 0 3 Mechanism of injury Radial Frequency 40.0 0 60.0 Mechanism of injury Radial Frequency 4 0 8 9 Mechanism of injury Radial Frequency 4 0 8 9 9 0.199 Mechanism of injury Radial Frequency 2 5 20 0 0.048 9 Median Frequency 1 0 11 0 11 9 0.048 9 1 0.86 0.886	damage		Frequency	4	0	5	0.012
Mechanism of injury Cut Frequency 5 5 36 $Percentage$ 10.9 10.9 78.3 0.199 Mechanism of injury Crushing Frequency 2 0 3 0.199 Crushing Frequency 2 0 3 0.199 Median Frequency 4 0 8 $Percentage$ 33.3 .0 66.7 Median Frequency 2 5 20 0.048 $Percentage$ 0.199 Age (years) Median Frequency 4 0 8 $Percentage$ 0.048 $30 < 23$ Percentage 7.4 18.5 74.1 0.048 Age (years) 230 Frequency 3 3 23 9.1 79.3 0.886 $30 < 30 < 230 < 230 < 230 < 230 < 230 < 230 < 230 < 230 < 230 < 230 < 230 < 230 < 230 < 230 < 230 < 230 < 230 < 230 < 230 < 230 < 230 < 230 < 230 < 230 < 230 < 230 < 230 < 230 < 230 < 230 < 230 < 230 < 230 < 230 < 230 < 230 < 230 < 230 < 230 < 230 < 230 < 230 < 230 < 230 < 230 < 230 < 230 < 230 < 230 < 230 < 230 < 230 < 230 < 230 < 230 < 230 < 230 < 230 < 230$	damage	Partial	Percentage	44.4	.0	55.6	1
Mechanism of injury Image Percentage 10.9 10.9 78.3 0.199 Crushing Frequency 2 0 3 0.199 Percentage 40.0 .0 60.0 60.0 60.0 Radial Frequency 4 0 8 8 Percentage 33.3 .0 66.7 66.7 Percentage 7.4 18.5 74.1 0.048 Percentage 7.4 18.5 74.1 0.048 Percentage 8.3 .0 91.7 0.048 Age (years) Esa0 Frequency 3 3 23 Bercentage 10.3 10.3 79.3 0.886		Cut	Frequency	5	5	36	
Mechanism of injury Frequency 2 0 3 0.199 Crushing Frequency 2 0 3 0 60.0 Percentage 40.0 .0 60.0 60.0 60.0 60.0 Frequency 4 0 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 6 66.7 5 20 0.048 6 6 9 6 6 9 6 6 6 6 6 6 7 1 6	N 1 · · · ·	-	Percentage	10.9	10.9	78.3	0.100
Crushing Percentage 40.0 .0 60.0 Radial Frequency 4 0 8 Percentage 33.3 .0 66.7 Percentage 33.3 .0 66.7 Percentage 7.4 18.5 74.1 Ulnar Frequency 1 0 11 Percentage 8.3 .0 91.7 0.048 Age (years) \leq 30 Frequency 3 3 23 Age (years) \leq 30 Frequency 4 2 16	Mechanism of injury	0.11	Frequency	2	0	3	0.199
Radial Frequency 4 0 8 Percentage 33.3 .0 66.7 67.7 67.7 67.7 67.7 67.7 67.7 67.7 67.7 67.7 67.7		Crushing	Percentage	40.0	.0	60.0	
The damaged nerve Median Percentage 33.3 .0 66.7 Median Frequency 2 5 20 Percentage 7.4 18.5 74.1 Ulnar Frequency 1 0 11 Percentage 8.3 .0 91.7 Age (years) \leq 30 Frequency 3 3 23 Age (years) \leq 30 Frequency 4 2 16		Radial	Frequency	4	0	8	
He damaged nerve Median Frequency 2 5 20 0.048 Median Frequency 2 5 20 0.048 Ulnar Frequency 1 0 11 0.048 Age (years) \geq 30 Frequency 3 3 23 Age (years) \geq 30 Frequency 3 3 23 Age (years) \geq 30 Frequency 4 2 16			Percentage	33.3	.0	66.7	
Ine damaged nerve Median Percentage 7.4 18.5 74.1 Ulnar Frequency 1 0 11 Percentage 8.3 .0 91.7 Age (years) \geq 30 Frequency 3 3 23 $Age (years)$ \geq 30 Frequency 4 2 16	771 1 1	N . 11	Frequency	2	5	20	0.040
Ulnar Frequency 1 0 11 Percentage 8.3 .0 91.7 $\lambda ge (years)$ ≥ 30 Frequency 3 3 23 $\lambda ge (years)$ ≥ 30 Percentage 10.3 10.3 79.3 $30 <$ Frequency 4 2 16 0.886	The damaged nerve	Median	Percentage	7.4	18.5	74.1	0.048
Olinar Percentage 8.3 .0 91.7 Age (years) \geq 30 Frequency 3 3 23 Age (years) \geq 30 Percentage 10.3 10.3 79.3 30<		T 11.	Frequency	1	0	11	
Age (years) ≥ 30 Frequency3323 $30 <$ $Percentage$ 10.310.379.30.886 $30 <$ $Frequency$ 4216 $Percentage$ 18.29.172.7		Ulnar	Percentage	8.3	.0	91.7	
Age (years) ≥ 30 $Percentage$ 10.3 10.3 79.3 0.886 $30 <$ Frequency 4 2 16 0.886			Frequency	3	3	23	
Age (years) $30 < \frac{\text{Frequency}}{2} \frac{100}{100} \frac{100}{100} \frac{100}{100} 0.886$		≥30	Percentage	10.3	10.3	79.3	
$30 < \frac{110}{\text{Percentage}} = \frac{182}{91} = \frac{91}{727}$	Age (years)		Frequency	<u>A</u>	2	16	0.886
		30<	Percentage	18.2	Q 1	72.7	-
Frequency 6 7 16 0.348			Frequency	6	2.1	16	0 348

Table 4: Relationship between sensory amplitude and patient's characteristics

to determine the prognostic factors of peripheral nerve injury confirm our findings ¹⁸.

In patients with low-level nerve injuries (forearm and wrist), the frequency of polyphasic waves was lower than in those with high-level injuries. Nerve regeneration occurs at a rate of 1 mm per day while muscle atrophy initiates immediately after denervation. Owing to the longer time needed for the motor endplate to be reinnervated in traumas to the proximal parts of the extremities; it is not

Variabla			Positive sh	Positive sharp wave	
	v ar lable		No	Yes	<i>P</i> -value
	Mala	Frequency	18	25	
Gender	Male	Percentage	41.9	58.1	0.713
	Female	Frequency	4	4	
	Temate	Percentage	50.0	50.0	
	Urban	Frequency	18	23	0.556
Place of residence		Percentage	43.9	56.1	
Thee of residence	Dravel	Frequency	4	6	0.550
	Kurai	Percentage	40.0	60.0	
	College or university	Frequency	2	3	
	degree	Percentage	40.0	60.0	
F1 (* 11 1	TT-1 1 1 1-1	Frequency	7	8	0 5 4 4
Educational level	High school diploma	Percentage	46.7	53.3	0.544
	Lower than a high school diploma	Frequency	13	18	
		Percentage	41.9	58.1	
	Wrist	Frequency	16	16	
		Percentage	50.0	50.0	
	Forearm	Frequency	2	12	
		Percentage	14.3	85.7	
Damaged organ	FIL	Frequency	1	0	0.007
Damageu organ	LIDOW	Percentage	100.0	.0	0.007
	A rm	Frequency	0	1	
		Percentage	.0	100.0	
	Shoulder	Frequency	3	0	_
	Shoulder	Percentage	100.0	.0	
	Complete	Frequency	16	26	4
Severity of nerve	Complete	Percentage	38.1	61.9	0.150
damage	Partial	Frequency	6	3	
	1 ai tidi	Percentage	66.7	33.3	

Table 5: Relationship between the presence of positive sharp waves and patient's characteristics

Variable		Positive sl	Positive sharp wave		
	variable		No	Yes	<i>P</i> -value
	Cut	Frequency	9	7	
M I		Percentage	19.6	15.2	0.641
Mechanism of injury	Current in a	Frequency	2	0	0.641
	Crusning	Percentage	40.0	.0	
	Radial	Frequency	7	5	
		Percentage	58.3	41.7	
	Madian	Frequency	10	17	
The damaged nerve	Wieulali	Percentage	37.0	63.0	0.559
	Ulnar	Frequency	5	7	-
	Cinur	Percentage	41.7	58.3	
	<20	Frequency	13	16	
Age (years)	<u>~</u> 30	Percentage	44.8	55.2	0.503
	30<	Frequency	9	13	-
		Percentage	40.9	59.1	
	1	Frequency	13	11	0.516
		Percentage	54.2	45.8	
	2	Frequency	1	3	
Duration between		Percentage	25.0	75.0	
injury and repair (days)	3	Frequency	4	7	
(auyo)		Percentage	36.4	63.6	
	4≤	Frequency	4	8	
		Percentage	33.3	66.7	
	>1	Frequency	1	0	
Duration between	<u></u>	Percentage	100.0	.0	
repair and	2-4	Frequency	5	8	0.727
electrodiagnostic		Percentage	38.5	61.5	0.727
studies (months)	>4	Frequency	16	21	_
	∠4	Percentage	43.2	56.8	
	Concrel	Frequency	3	8	
	General	Percentage	27.3	72.7	
Surgeon's enerialty	Plastic	Frequency	17	12	0.034
Surgeon's specialty		Percentage	58.6	41.4	
	Orthopedics	Frequency	2	9	
	Ormopeales	Percentage	18.2	81.8	

surprising that they are associated with poorer motor recovery ^{8, 19}.

Consistent with the prior assumptions, patients with partial injury showed a higher chance of presenting normal sensory amplitude than those with complete injury. In severe limb trauma, which leads to complete nerve injury, multiple tissues are usually damaged. Peripheral nerve components of this mixed injury type are often the most difficult to diagnose and treat. This fact is justified by the difficulty in differentiating partial from complete damages without surgical exploration and the dubious nature of nerve healing ^{20, 21}.

In the current study, the majority of patients with ulnar nerve injury showed no sensory amplitude. A vast body of evidence indicates that the outcome of radial nerve injuries is better than the median nerve and the ulnar nerve has the poorest prognosis. However, the existing data are mostly focused on the motor component of the nerves, and there is a lack of data on factors affecting the rate of recovery of peripheral nerve function after primary repair due

¥7 · 11			Polyphasic wave		D 1
	variable		Yes	No	<i>P</i> -value
	N/ 1	Frequency	21	22	
	Male	Percentage	48.8	51.2	0.626
Gender	F 1	Frequency	4	4	
	Female	Percentage	50.0	50.0	_
Place of residence	TT 1	Frequency	21	20	
	Urban	Percentage	51.2	48.8	0.725
	Dunal	Frequency	4	6	
	Kurai	Percentage	40.0	60.0	
	College or	Frequency	3	2	
	university degree	Percentage	60.0	40.0	
	High school	Frequency	7	8	-
Educational level	diploma	Percentage	46.7	53.3	0.836
	Lower than a	Frequency	15	16	1
	high school diploma	Percentage	48.4	51.6	
		Frequency	17	15	0.014
	W rist	Percentage	53.1	46.9	
	Forearm	Frequency	3	11	
		Percentage	21.4	78.6	
	Elbow	Frequency	1	0	
Damaged organ		Percentage	100.0	.0	
	Arm	Frequency	1	0	
		Percentage	100.0	.0	
	Shoulder	Frequency	3	0	
		Percentage	100.0	.0	
	Committee	Frequency	18	24	
Severity of nerve	Complete	Percentage	42.9	57.1	0.075
damage	D (1)	Frequency	7	2	0.075
	Partial	Percentage	77.8	22.2	
	Cut	Frequency	22	24	
Mashanian C'		Percentage	47.8	52.2	0.00
mechanism of injury	Com 1	Frequency	3	2	0.668
	Crushing	Percentage	60.0	40.0	1
	Radial	Frequency	8	4	
		Percentage	66.7	33.3	1
The damaged nerve	Mal	Frequency	12	15	0.404
	wiedian	Percentage	44.4	55.6	0.404
	TTI	Frequency	5	7	
	Uinar	Percentage	41.7	58.3	1
	>20	Frequency	15	14	
A and (man and)	≥30	Percentage	51.7	48.3	0 770
Age (years)	20 ·	Frequency	10	12	0.//9
	30<	Percentage	45.5	54.5	1
		Frequency	13	11	0.710

Table 6: Relationship between the presence of polyphasic waves and patient's characteristics

V			Polypha	Polyphasic wave	
variable			Yes	No	<i>P</i> -value
	1	Percentage	54.2	45.8	
	2	Frequency	2	2	
Duration between	2	Percentage	50.0	50.0	
injury and repair	2	Frequency	6	5	
(days)	3	Percentage	54.5	45.5	
	47	Frequency	4	8	
	4≤	Percentage	33.3	66.7	
	≥2	Frequency	1	0	
Duration between		Percentage	100.0	.0	
repair and electrodiagnostic	2-4	Frequency	5	8	0 523
		Percentage	38.5	61.5	0.525
studies (months)	≥4	Frequency	19	18	
		Percentage	51.4	48.6	
	Conoral	Frequency	3	8	
Surgeon's specialty	General	Percentage	27.3	72.7	
	Plastic	Frequency	18	11	0.091
	riastic	Percentage	62.1	37.9	0.091
	Orthonedics	Frequency	4	7	
	Ormopeates	Percentage	36.4	63.6	

to penetrating trauma of the upper limb ^{22, 23}.

Based on the findings of this study, the duration between injury and repair did not appear to have a significant influence on the surgical outcomes. However, it should be noted that the majority of our subjects had undergone nerve repair within days of injury, while many studies have demonstrated that delay of up to 6 months does not affect the repair outcomes¹⁹.

The patients operated by plastic surgeons showed the highest frequency of normal motor amplitude and the lowest frequency of positive sharp waves. Peripheral nerve injury is a multi-disciplinary condition, which can be managed by several clinical disciplines, including plastic surgeons, orthopedic surgeons, and neurosurgeons. Although surgeon's experience can highly affect the surgical success rate, the surgeon's specialty has not been linked to the patient's outcomes previously ^{24, 25}. Hence, our finding may be due to the limited sample size in this study.

LIMITATIONS

The limitation of this study was the use of data from a single center and limited sample size. However, different demographic and clinical variables were investigated to aid in determining the prognostic factors of nerve injury in the studied population.

CONCLUSION

Factors affecting the outcome of peripheral nerve repair following penetrating trauma to the upper extremity include age, education, the type of damaged nerve, the severity of the injury, and the surgeon's specialty.

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None

CONFLICT OF INTEREST

The authors attest that they have no conflict of interest to declare.

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