

# The effect of injury level, associated injuries, the type of nerve repair, and age on the prognosis of patients with median and ulnar nerve injuries

## Önkol median ve ulnar sinir yaralanmalarında yaralanma seviyesi, ek patolojiler, sinir onarımı türü ve yaşın prognoza etkileri

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**Amaç:** Bu çalışmada, önkol median ve/veya ulnar sinirin düzgün tip yaralanmalarında onarım sonrası elde edilen fonksiyonel sonuçlar değerlendirildi ve önkol yaralanma seviyesi, ek patolojiler, primer ya da sekonder onarım ve yaşın bu sonuçlar üzerine etkisi incelendi.

**Çalışma planı:** Önkolda düzgün kesili lezyonlar nedeniyle tedavi edilen 42 hasta (34 erkek, 8 kadın; ort. yaş 31; dağılım 9-62) geriye dönük olarak incelendi. Yaralanmalar dört hastada önkolda proksimal, 11'inde orta, 27'sinde distal seviyedeydi. Yaralanan sinir sayısı 51 idi; bunların 30'unda median sinir, 21'inde ulnar sinir etkilenmişti. On iki olguda izole sinir yaralanması, dokuz olguda sinir ve tendon kesisi, 21 olguda ise sinir, tendon ve arter yaralanması saptandı. Hastalar, 0-15, 16-30, 31-45, 46 ve üzeri olmak üzere dört yaş grubunda incelendi. Fonksiyonel değerlendirmede Seddon ölçütleri kullanıldı. Kesi seviyesi, ek patolojiler, primer ve sekonder onarım ve yaşın sonuçlar üzerindeki etkisi incelendi. Ortalama izlem süresi 39 ay (dağılım 11-57 ay) idi.

**Sonuçlar:** Primer ve geç primer onarım yapılan hastalarda klinik ve fonksiyonel sonuçlar sekonder onarım yapılanlara göre daha kötü bulundu; ancak, bu fark istatistiksel olarak anlamlı değildi ( $p>0.05$ ). Yaralanma seviyesinin, türünün ve yaşın Seddon değerlendirme sonuçlarını anlamlı derecede etkilemediği görüldü ( $p>0.05$ ). Ancak, 0-15 yaş arası tüm olgularda (%100) çok iyi sonuç alınırken, 46 yaş üzeri olgularda ise iyi ve çok iyi sonuç oranı %20 idi.

**Çıkarımlar:** Periferik sinir düzgün kesilerinde uygun olgularda öncelikle primer onarım tercih edilebilir. İleri yaştaki olgularda sinir rejenerasyon potansiyeli düşük olduğundan, bunlarda öncelikli olarak rekonstrüktif girişimlerin düşünülmesi gerekir.

**Anahtar sözcükler:** Arter/cerrahi; median sinir/yaralanma/cerrahi; tendon yaralanması/cerrahi; travma, sinir sistemi/rehabilitasyon; ulnar sinir/yaralanma/cerrahi; el bileği yaralanması/cerrahi.

**Objectives:** In this study, we aimed to evaluate the functional results of nerve repair (median and/or ulnar) in patients with forearm clean-cut injuries and investigated the effect of injury level, associated injuries, the type of repair (primary or secondary), and age on the prognosis.

**Methods:** The study included 42 patients (34 males, 8 females; mean age 31 years; range 9 to 62 years) who were treated for forearm clean-cut injuries. Involvement was in the proximal forearm in four, mid-forearm in 11, and distal forearm in 27 cases. There were 51 nerve injuries affecting the median nerve ( $n=30$ ) and the ulnar nerve ( $n=21$ ). Nerve injuries were isolated in 12 patients, associated with tendon injuries in nine patients, and with tendon and artery injuries in 21 patients. The patients were evaluated in four age groups including 0-15, 16-30, 31-45 years, and 46 years or above. Functional evaluations were made using the Seddon classification. The effect of injury level, associated injuries, the type of repair, and age on the prognosis was assessed. The mean follow-up was 39 months (range 11 to 57 months).

**Results:** Although the clinical and functional results of primary and late-primary repairs were less favorable than those of secondary repairs, the difference did not reach a significant level ( $p>0.05$ ). The injury level, associated injuries, and age did not influence the Seddon scores significantly ( $p>0.05$ ). In the age group of 0-15 years, the results were very good in all the patients (100%), but good and very good results accounted for only 20% in the age group of 46 years or above.

**Conclusion:** In appropriate cases with clean-cut nerve injuries, primary repair must be the first choice. Taking the low regeneration capacity into consideration, priority should be given to reconstructive procedures in patients at older ages.

**Key words:** Arteries/surgery; median nerve/injuries/surgery; tendon injuries/surgery; trauma, nervous system/rehabilitation; ulnar nerve/injuries/surgery; wrist injuries/surgery.

Clean-cut injuries of forearm may cause severe functional disability because tendon and muscle injury is frequently accompanied by vascular and nerve injuries. These structures are rather superficial, thus even relatively mild injuries may cause extensive damage. It is not always possible to obtain the desired outcome, especially in case of nerve injuries even though delicate repair by microsurgical techniques and postoperative vigorous physiotherapy is employed. Non-functional extremity with sensory and motor impairment may be the end-result in these patients. Thus, great care must be taken for initial examination, treatment and postoperative rehabilitation of these injuries.<sup>[1]</sup>

In this study we evaluated the functional results of repair of median and/or ulnar nerve clean-cut type injuries in the forearm and the effect of variables such as injury level, associated pathologies (tendon-artery injuries), primary or secondary repair and age on the prognosis.

### Patients and method

Forty two patients (34 males, 8 females; mean age 31; range 9 to 62) who attended their last visit, out of total 53 patients who was presented to the emergency department for a cut on the volar surface of forearm between June 1999 and July 2004 were retrospectively evaluated. Right hand was injured in 23 patients and left hand was injured in 19 patients. Dominant hand was injured in 25 cases and non-dominant hand was injured in 17 cases. As for the level of injury, regular clean-cut lesions were located at the proximal one third of the forearm in 4 cases; middle one third in 11 cases, distal one third in 27 cases. Contaminated or crush injuries were not included into the study. Total number of injured nerve was 51; 30 of these were median nerve (six of them partial), and 21 were ulnar nerve (one partial) lesions. Patients were classified into three groups for associated pathologies: isolated nerve injury (n=12); nerve and tendon injury (n=9); nerve, tendon and artery injury (n=21).

Repairs were classified according to time period between injury and the surgery: repairs performed within 24 hours were classified as primary repair, repairs performed within 1 to 7 days were classified as late primary repair, and repairs performed 1 week after injury were classified as secondary repairs.

Primary repair has been performed for 30 peripheral nerves; in one case of median nerve injury late primary repair was preferred.<sup>[2]</sup> Eleven of the secondary repairs were end-to-end repairs; five nerves were repaired by sural nerve grafts with a mean length of 3.4 cm (range 2 to 5 cm). Patients were divided into four groups according to their age (0-15 years, 16-30 years, 31-45 years, over 46 years).

Cases presented directly to our clinic after injury was taken into OR within 6 hours and primary debridement and repair were performed. Mean period of time between the injury and the surgery was 31 days (range 0 to 314 days). Surgery was performed under microscope or loop magnification, after tourniquet placed to proximal arm was inflated, and wounds were continuously irrigated by antibiotic added saline (gentamycine). End-to-end repairs were achieved by epiperineural suture technique using 8/0 and 9/0 suture materials, and secondary repairs with sural grafts were achieved by interfascicular and group fascicular suture technique using 9/0 and 10/0 suture materials. Proximal and distal parts of the repaired nerves were slightly released to prevent undue tension in the repair zone. Patients were immobilized by a long arm cast for three weeks and rehabilitation was started in the rehabilitation clinic for nerve and/or tendon repaired cases. Prophylactic antibiotic was used for all of the operated cases and if an artery was repaired Aspirin 2x300 mg/day plus Rheomacrodex infusion was administered for the first five days.

Patients were examined weekly for the first six weeks and monthly for 3 months and at three months interval thereafter. In the follow-up examination, wound was inspected, nerve regeneration was assessed by Tinel test; sensory function was assessed by Semmes-Weinstein monofilament test and static two point discrimination test; motor function and grasp strength was assessed by Jamar dynamometer. Sensory re-education was provided when electrotherapy or nerve regeneration has reached in the hand. Ulnar paralysis splint has been used for ulnar nerve repair cases until regeneration has been accomplished in order to prevent claw hand. Patients were informed to use moisturizing creme until sweating of the hand returned and warned to be alert for accidental injuries when protective sensory function was deficient.

**Table 1.** Criteria for functional results

Result	Motor strength	Sensory function	Seddon
Very good	5°	Same as normal side; no deformity or trophic change; stereognosis good, no hypersensitivity; static two-point discrimination is same with other hand	(4) Strength 5 Sense 4
Good	4-5°	Grasp at proper speed; improvement of paralysis; soft/hard discrimination or recognize objects; increased sensitivity to mild or excessive cold; mild atrophy of pulps; static two-point discrimination at finger tip ≤ 8 mm.	(3) Strength 5 Sense 3+
Moderate	≥3°	Sufficient grip with fingers; partial sweating; stereognosis absent; pulp atrophy; prominent cold sensitivity; static two-point discrimination > 8 mm;	(2) Strength 3 Sense 3
Poor	≤3°	Absence of sensory function or severe cold sensitivity; sweating; trophic changes	(1) Strength 0-1 or 2 Sense 0-1 or 2

Functional status of the patients was assessed by Seddon classification (Table 1).<sup>[3]</sup> Mean follow-up period was 39 months (range 11 to 57 months). Statistical analysis were performed by Mann-Whitney U-test and unpaired t-test in SPSS 11.0 software;  $p < 0.05$  was accepted as statistically significant.

## Results

Injury involved dominant extremity in 60% and non-dominant extremity in 40% of the cases. Although difference between the grasp strength of the injured and non-injured extremity was 36%, it was not statistically significant ( $p > 0.05$ ). Eight cases with reduced protective sensation and three cases without any protective sensation in the Semmes-Weinstein test were not satisfied with the outcome. These cases had deformities and trophic changes. Nine cases had

limitation in the range of motion of wrist and hand joints. Four cases with ulnar nerve repair developed claw hand deformity. Thenar-hypothenar atrophy was observed in the innervation zone of the injured nerve.

Results of the 35 cases with primary repair was found to be very good in 10 cases (29%; 8 median, 2 ulnar), good in 13 (37%; 10 median, 3 ulnar), moderate in 6 (11%; 1 median, 5 ulnar), poor in 6 (17%; 3 median, 3 ulnar) according to Seddon outcome measures.

Results of the 11 cases with secondary end-to-end repair were very good in 6 (55%; 2 median, 4 ulnar), good in 3 (27%; 1 median, 2 ulnar), moderate in 1 (9%; median), and poor in 1 case (median).

Results of the 5 cases with secondary sural graft repairs were very good in 2 cases (40%, median, ulnar), moderate in 1 case (20%, median); poor in 2 cases (40%, median) (Table 2).

**Table 2.** Distribution of repaired median and ulnar nerves according to Seddon criteria

Seddon	Nerve	Primary		Secondary		Graft		Total	
		Number	Percent	Number	Percent	Number	Percent	Number	Percent
Very good	Median	8	73	2	18	1	9	11	22
	Ulnar	2	29	4	57	1	14	7	14
Good	Median	10	91	1	9	–	–	11	22
	Ulnar	3	60	2	40	–	–	5	10
Moderate	Median	1	33	1	33	1	33	3	5
	Ulnar	5	100	–	–	–	–	5	10
Poor	Median	3	50	1	17	2	33	6	12
	Ulnar	3	100	–	–	–	–	3	5
<b>Total</b>		35	69	11	22	5	9	51	100

**Table 3.** Comparison of primary-late primary and secondary repair for cold intolerance, frequency of deformity, presence of trophic changes, satisfaction with clinical results and return to work and ratio of moderate and poor results according to Seddon scale

	Primary-late primary		Secondary		Total
	Number	Percent	Number	Percent	
Cold intolerance	18	51	5	46	23
Presence of deformity	13	37	3	27	16
Trophic changes	16	46	4	36	20
Not satisfied	11	31	3	27	14
Not returned to work	9	26	3	27	12
Seddon (moderate-poor)	8	23	3	27	12

Clinical and functional outcomes (cold intolerance, frequency of deformity, presence of trophic changes, satisfaction with clinical results and return to work) of primary and late primary repair patients were inferior compared to secondary repair patients. But, this difference was not statistically significant ( $p>0.05$ ; Table 3). There was no statistically significant difference between these treatment modalities according to Seddon criteria as well ( $p>0.05$ ).

Isolated nerve injuries were common in proximal and middle one third of the forearm (58%), tendon and arterial injuries frequently accompanied nerve injuries (76%) in distal one third of the forearm close to the wrist. There was no statistically significant difference between isolated nerve and nerve-tendon-artery injuries according to Seddon criteria ( $p>0.05$ ; Table 4).

Age group was not associated with the clinical and functional results ( $p>0.05$ ; Table 5). But, very good results were obtained in all of the 0-15 age group (100%) while this ratio was only 20% in the cases over 46 years old.

### Discussion

Healing capacity of peripheral nerves has been shown a hundred years ago. Introduction and wide

employment of microsurgical techniques in the last 20 years has provided distinct improvement in diagnosis and treatment. Widely accepted basic principles of peripheral nerve repair can be expressed as, doing the repair with appropriate suture material and instruments under magnification (microscope, loop); prevention of tension in repair zone; interposition of a neural graft when there is defect between the nerve ends; prevention of postural movements to avoid tension in repair zone; to attempt primary repair if clinical and surgical conditions are appropriate, or arrange a secondary repair otherwise; group fascicular repair if intraneural anatomy is suitable, if not prefer epineural repair and take up vigorous sensory and motor re-education after nerve repair.<sup>[3]</sup> Functional improvement after peripheral nerve repairs is reported to be associated with age of the patient, time period between injury and repair, level of injury (proximal or distal), injury mechanism (crush, avulsion or clear-cut), injured nerve (median, ulnar), injured nerve type (only motor, only sensory or mixed type nerve).<sup>[4]</sup>

Millesi<sup>[5]</sup> stated that best results for the regular cuts of peripheral nerve injuries without defect can be achieved by primary epineural repair, and if a tendon injury accompanies nerve injury, primary repair

**Table 4.** Comparison of additional pathologies according to level of forearm and Seddon assessment results

Classification according to additional pathologies	Level of injury in the forearm				Seddon result			
	Proximal-middle one third		Distal		Moderate-poor		Good-very good	
	Number	Percent	Number	Percent	Number	Percent	Number	Percent
Isolated nerve injuries (n=12)	7	58	5	42	4	33	8	67
Nerve+tendon injuries (n=9)	3	33	6	67	2	22	7	78
Nerve+tendon+arterial injuries (n=21)	5	24	16	76	6	29	15	71
Total	15		27		12		30	

**Table 5.** Comparison of age groups for clinical and functional results

Age groups	Seddon assessment system			
	Moderate-poor		Good-very good	
	Number	Percent	Number	Percent
0-15	–	–	5	100
16-30	5	33	10	67
31-45	3	18	14	82
≥46	4	80	1	20
<i>Total</i>	12		30	

of these injuries may impede the functional results due to adhesions between tendon and nerve; thus it is suggested to employ secondary nerve repair in these cases. However there are numerous studies which claim better results by primary repair and early passive motion protocols both in isolated nerve injuries and nerve injuries associated with tendon injuries.<sup>[5-10]</sup> Although experimental studies on early mobilization have shown that mobilization within first 3 weeks has a negative effect on nerve regeneration, no difference was observed between early mobilized and immobilized cases in terms of adhesions between nerve and tendons.<sup>[11-13]</sup> In this study we performed primary repair for regular cuts; immobilized the extremity for three weeks in long-arm cast, and started passive mobilization. Results of primary or late primary repair is somewhat inferior to secondary repairs in terms of cold intolerance, frequency of deformity, presence of trophic changes, satisfaction with clinical results and return to work; but difference is not statistically significant ( $p>0.05$ ). In addition treatment modalities did not produce significant difference between the groups according to Seddon criteria ( $p>0.05$ ; Table 3).

Penetrating and cutting injuries of the forearm frequently lead to tendon, muscle and vascular injuries as well as isolated nerve injuries. Primary repair of these cases may result in functional limitations due to adhesions between tendons and the surrounding tissue.<sup>[14,15]</sup> Secondary repair of nerve injuries,<sup>[16]</sup> primary repair of all structures with postoperative early passive mobilization,<sup>[8,9]</sup> and at least three weeks of immobilization after primary repair followed by passive and active mobilization<sup>[12]</sup> has been suggested to avoid the complications of these additional pathologies. In our study isolated nerve

injuries were commonly observed at proximal forearm whereas nerve and tendon injuries were observed in middle one third of forearm and nerve, tendon and arterial injuries were observed in distal one third of the forearm. All our cases were immobilized for three weeks after primary repair and then patients were asked to start passive movements in night splints. No difference has been observed between the Seddon evaluation results of the three groups formed according to associated pathologies ( $p>0.05$ ; Table 4).

Some studies in the literature propose that functional outcomes of the forearm clean-cut injuries deteriorate as the lesion shifts to proximal.<sup>[13,17,18]</sup> Although a significant difference is not observed, we think that better outcomes for isolated nerve injuries can be explained by more frequent localization of these injuries in proximal and middle parts of the forearm whereas less successful results in tendon and/or arterial injuries may be associated with more frequent location in the distal one third of the forearm (Table 4).

Rate and quality of healing after peripheral nerve surgery has been shown to be inversely related to increasing age.<sup>[4,6,19]</sup> In our study, no association could be established between the age group and clinical and functional results according to Seddon criteria ( $p>0.05$ ). But results were very good in all cases of 0-15 age group (%100), where good and very good results remained about 20% in the cases above 46 years old (Table 5).

Atraumatic repair by an experienced hand surgeon may not be sufficient in peripheral nerve injuries; postoperative sensory re-education is essential to regain sensory function. This approach has been proven to improve cortical reorganization especially in cases between 0 to 18 years of age.<sup>[20,21]</sup> In all cases regeneration of repaired ulnar and median nerves is assessed by Tinel test and sensory re-education was started when Tinel sign reached to the palm. Sensory examination by Semmes-Weinstein monofilament test showed decreased protective sensation in 8 cases and total absence of protective sensation in 3 cases. These patients had deformities and trophic changes and all were unsatisfied with the results. Range of motion of the wrist and the hand joints were limited in 9 cases. Claw hand deformity

developed in 4 cases of ulnar nerve repair. Thenar-hypothenar atrophy was observed in innervation zone of the injured nerve in 11 cases.

As for conclusion, primary repair should be preferred in appropriate cases with a regular cut of peripheral nerves; otherwise secondary repair should be arranged. Older patients with peripheral nerve injury have reduced potential for healing, thus we believe that reconstructive operations are justified in these cases.

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