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# Long-term functional results after radial nerve repair

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**Objective:** This study aimed to evaluate the functional results of end-to-end repairs in radial nerve injuries.

**Methods:** The study included 18 (15 males, 3 females) patients who underwent middle level end-to-end radial nerve repair and who responded to our final follow-up call. Patients' average age was 30 (range: 16 to 43) years. The average time lapse between injury and repair was 25.1 days (range: 1 day to 13 months). Pinch and grip strength measurements were graded according to the modified Verga classification. The Highet classification was used for the evaluation of sensorial recovery. Functional outcome were assessed with the DASH-T score. Average follow-up time was 62.5 (range: 24 to 156) months.

**Results:** Motor function according to the Verga classification was excellent in 16 patients and poor in two. Pinch and grip power measurement comparison of the two sides in the 16 patients with excellent results showed a respective 24.1% and 14.3% decrease on the affected side. According to Highet's classification, sensorial evaluation was S4 in seven patients, S3+ in four, S3 in three, S2+ in one, S2 in one, and S1 in two patients. The average DASH-T score of patients with excellent results was 7.3.

**Conclusion:** Radial nerve repairs, if done end-to-end using an appropriate technique, may lead to nearly full recovery in younger patients.

**Key words:** End-to end-repair; radial nerve.

The radial nerve is the largest terminal branch of the posterior cord of the brachial plexus and its motor function is more important than its sensory one; thus, repair success can be determined by the recovery of motor function.[1-3] Shergill observed that radial nerve injuries were generally seen at the intermuscular septum of the mid-humerus and were most frequently caused by sharp objects. In addition, the nerve may be injured by long bone fracture, surgery or gunshot wound.[4]

Treatment is determined according to injury type. While early exploration is advocated in open injuries, there is still some controversy regarding the appropriate approach in closed injuries. Some authors argue that exploration of the nerve is necessary in radial nerve paralysis caused by open injuries and that an observation period of 3 to 6 months must be applied in closed nerve paralysis.[3,5] Shao determined an 88.1% rate of spontaneous recovery in closed injuries.[5]

Post-reduction palsy, generally seen with open or pathologic fractures and floating elbow or vascular injuries, requires early exploration.[3,6-9] Autologous nerve grafting and nerve transfer are performed in radial nerve injuries where end-to-end nerve repair cannot be performed.[1,2,4-6,10] Tendon transfer is only performed in neglected cases and in cases with poor functional outcome after nerve repair.[11-14]

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Because of the long and variable reinnervation period the evaluation of the functional outcome is not straightforward after radial nerve repairs. In this study, we aimed to evaluate the long-term functional results of end-to-end repair in middle level radial nerve injuries.

## Patients and methods

The study included the 18 patients who responded to the final follow-up call of a total of 22 patients who had undergone end-to-end repair of the radial nerve between 1993 and 2007. Fifteen patients were male and 3 were female. Mean age was 30 (range: 16 to 43) years.

Cause of injury was a sharp object (glass or knife) in 14 patients, workplace accident in 2, traffic accident in 1, and iatrogenically induced in 1 patient. Fourteen patients had open nerve injuries.

The nerve injury was accompanied by a humerus fracture in 4 patients, a soft tissue injury in 12 patients, a median nerve injury in 7 patients, and a brachial artery injury in 6 patients. Primary repair was performed in 13 patients and secondary nerve repair was performed in 5. In 3 patients, tightness at the repair area was reduced by shortening the bone. The mean interval between injury and surgical repair was 25.1 days (range: 1 day to 13 months).

Nerve recovery time was determined as the time required for the return of motor or sensory function. Wrist extension was measured for motor function and sensation changes on the dorsal thumb for sensory function. Grip strength was evaluated using a Jamar dynamometer (Jamar Hydraulic Hand Dynamometer; Sammons Preston Patterson Medical Products, Inc., Bolingbrook, IL, USA) and pinch strength was evaluated using a "Preston pinch gauge" (Baseline Pinch Gauge; B&L Engineering, Tustin, CA, USA).[10,12] Grip and pinch strength were measured by stabilizing the patient's shoulder with the elbow in 90 degrees of flexion with the wrist in a neutral position. Ten percent of grip strength and 5% of pinch strength of the dominant hand was extracted during the separate measurements for both hands to standardize the measurements.[10,13] The BMRC (British Medical Research Council) muscle power evaluation system was used to evaluate motor and sensory recovery.[1,2,14-21] Thumb extension and abduction were measured as the thumb opening angle.[18] Results were evaluated using a modification of the Verga classification (Tables 1 and 2).[18]

The DASH-T questionnaire was used in the evaluation of upper extremity function.[19] The self-administered questionnaire is scored on a scale of increasing disability from 0 to 100.

## Results

Mean postoperative follow-up time was 62.5 (range: 24 to 156) months and mean interval to nerve recovery was 6.1 (range: 4 to 9) months.

In 16 of the 18 patients the BMRC wrist extension power was measured at level M4-M5 and the metacarpophalangeal joint (MCP) extension power at M4-M5. Thumb opening angle was measured between 55 and 70 degrees in 15 patients.

According to the modified Verga classification, 2 patients had insufficient recovery and tendon transfer was advised to these patients (Table 3).

BMRC results were S4 in 7 patients, S3+ in 4 patients, S3 in 3 patients, S2+ in 1 patient, S2 in 1 patient and S1 in 2 patients.

The Verga classification score was excellent in 16 patients when the difference between the grip strength of the affected and unaffected side was less than 14.3% and the power strength decreased by less than 24.1%.

The mean DASH score of the patients with excellent results was 7.3. DASH scores were higher in patients with no recovery. The 3 concurrent humerus fractures healed without any complication.

**Table 1.** Modified Verga classification.

| | Scoring | | | |
|---|---|---|---|---|
| | 4 | 3 | 2 | 1 |
| Wrist extension strength | M4–M5 | M3 | M2 | M0–M1 |
| MCP extension strength | M4–M5 | M3 | M2 | M0–M1 |
| Thumb opening angle | 70°<X>55° | 55°<X>35° | 35°<X>20° | <19° |

[1]According to BMRC. **MCP:** Metacarpophalangeal joint.

## Discussion

Radial nerve repair results are affected by patient's age, injury level and cause of injury, defect length, repair type, surgical experience, and the interval between injury and repair.[2,20-23] In the literature, a significant difference has been observed between recovery rates in open nerve (85.7%) and closed nerve (97.1%) injuries.[5]

Low-level posterior interosseous nerve injuries recover with excellent results as the nerve-end length is short. For posterior interosseous nerve repairs, Shergill et al. reported good results in 89% of patients, but good results in only 31% of middle level injury repairs.[4] In their review, Shao et al. reported a recovery rate of 52.9% after neurorrhaphy performed in radial nerve repairs accompanied by humerus fractures.[5]

Pan et al.[24] examined the results of 104 patients with middle level radial nerve injuries, who were treated with neurolysis, nerve graft or neurorrhaphy (22 patients underwent neurorrhaphy). A power level of M3 or more was found for wrist extension in 93%, for finger extension in 86%, and for thumb extension in 83% of the patients. Murovic reported that 23 patients out of 27 had healed after performing neurorrhaphy at arm level.[25]

According to the Verga classification, excellent recovery was detected in 16 (88.8%) of our 18 patients who underwent middle level end-to-end nerve repair. Post-repair wrist extension strength was determined at M4-M5 in 16 patients (88.8%).

The combination of extension and abduction needed for a healthy and functional thumb can be evaluated by observing the angle between thumb and second finger (Table 1). In our series, this angle was 50-70 degrees in 15 patients, 20-55 degrees in 1 patient, and less than 20 degrees in 2 patients.

Recovery time in our study was a mean of 6.1 months which was in line with Shao et al.'s findings.[5]

Tendon transfer indications are nerve injuries that cannot be primarily repaired, negative clinical and electromyographic findings 6 months after neurolysis or nerve repair, and cases that necessitate a quick return to normal function. The necessity for more than one muscle transfer, muscle imbalance, and extensor muscle tightness are possible complications of tendon transfers.[26-29] Nerve repair, however, allows for full recovery without sequela or complication. It has been shown in the literature that full radial nerve function has never been obtained through tendon transfer.[24,29] In elderly patients and cases with a long innervation path (high-level radial nerve palsy), post-recovery tendon transfer may be a viable option.[3]

**Table 2.** Evaluation criteria according to modified Verga classification.

| | Scores |
|---|---|
| Excellent | 12≤X≥10 |
| Good | 9≤X≥7 |
| Fair | 7≤X≥4 |
| Poor | ≤3 |

The interval between injury and surgery is a leading factor affecting clinical results.[30] In our series, the mean interval was 25.1 days (range: 1 day to 13 months). The interval between injury and surgery was excessive in 2 patients (9 and 13 months). While results here were non-conclusive, a waiting period of 6 or 7 months before secondary repair surgery in younger and particularly tolerant patients can be applied.

Recovery can also be negatively affected by ischemia and fibrosis in muscles, caused by possible accompanying vascular injuries in the middle region of the radial nerve in which there is no nutritive artery.[4] Brachial artery injuries were detected in 6 of our study patients and the clinical signs and symptoms delayed the diagnosis in one patient. As expected, recovery quality and patient satisfaction were affected by double forearm fractures, condyle fractures, and injuries of the median artery and nerve.

Other possible accompanying complications are humerus fractures (Figs. 1 and 2). Humerus fractures, open or closed, affect recovery workflow. Ring et al.[31] observed that most humerus fractures are often coupled with serious crush injuries and

**Table 3.** Functional results after nerve repair.

| | End-to-end repair | | | |
|---|---|---|---|---|
| | Excellent | Good | Poor | Fail |
| WES | 16 | 1 | 1 | 0 |
| MES | 15 | 0 | 1 | 2 |
| TOA | 15 | 1 | 2 | 0 |

**WES:** Wrist extension strength; **MES:** Metacarpophalangeal joint extension strength; **TOA:** Thumb opening angle.

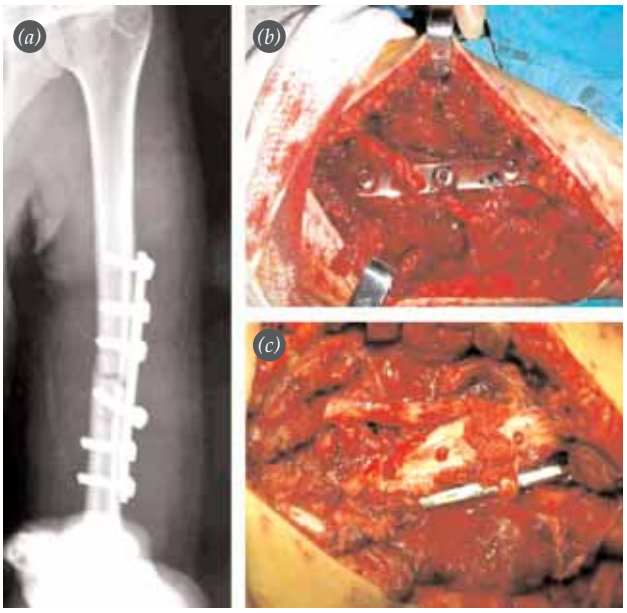


**Fig. 1.** **(a, b)** 25-year-old female patient with an unhealed humerus fracture, **(c)** end-to-end repair and transfer of the nerve, shortening of distal fractures and osteosynthesis with plate. [Color figure can be viewed in the online issue, which is available at www.aott.org.tr]

**Fig. 2.** Radiological and clinical views of the patient from Fig 1. [Color figure can be viewed in the online issue, which is available at www.aott.org.tr]

amputations. They noted that while exploration of the nerve was necessary, they had a 0 recovery success rate in 5 attempts at end-to-end nerve repair. In our series, 2 patients presented with high-energy humerus fractures. One underwent nerve repair after soft tissue recovery, and achieved an excellent result. In the other patient, a 4 cm shortening of the humerus fracture and end-to-end nerve repair were performed and excellent recovery was also achieved.

Iatrogenic radial nerve palsy was seen in 1 patient (Figs. 3 and 4). The dysfunctional nerve was anteromedialized and repaired, and excellent recovery was achieved. Wang et al. suggested a waiting period of four months before considering further exploration for cases of post-surgery iatrogenic radial nerve palsy in patients with accompanying following humerus fractures.[32] However, in our clinical practice, we also use ultrasound to assess the integrity of the radial

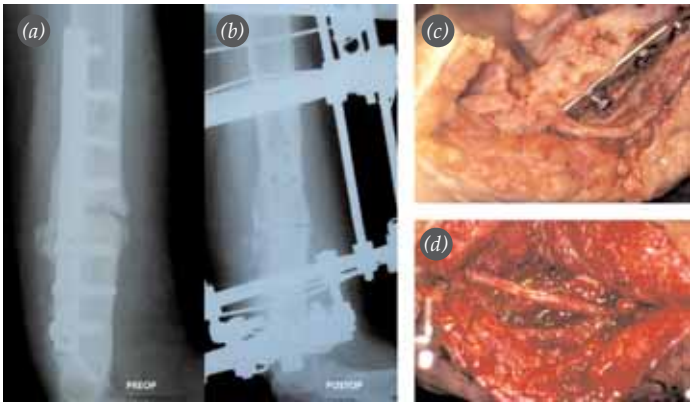


**Fig. 3.** **(a)** Preop and **(b)** postop views of the 21-year-old female patient with an unhealed humerus fracture, **(c, d)** intraop views showing the plate against the nerve and end-to-end repair. [Color figure can be viewed in the online issue, which is available at www.aott.org.tr]

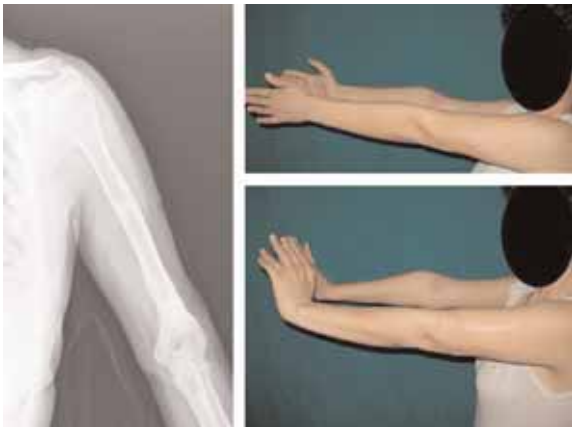

**Fig. 4.** Radiological and clinical views of the patient from Fig 3. [Color figure can be viewed in the online issue, which is available at www.aott.org.tr]

nerve. Soft tissue ultrasound can be used in radial nerve palsies that occurs after the injury (primary) or after reduction of fractures (secondary).[33,34] Surgical exploration of the nerve should be considered when the integrity of the nerve cannot confirmed by ultrasound or in patients with neuroma.

The DASH score is a widely used outcome scale in the assessment of upper extremity function. Hunsaker found an average DASH score of 7 points in a normal population with no clinical complaints.[35] In our series, the patients with excellent and good recovery results had an average DASH score of 7.3 points, showing a minimal impact of the injury on daily life. After recovery, all patients returned to work. In Altintas et al.'s study the mean DASH score was 16(±10) points after tendon transfer.[13] These results show that nerve repair, performed at the proper time, enables recovery with no need for tendon transfer and provides a more satisfying result.

Although decreasing pinch strength is expected in long-term nerve injuries, it did not adversely affect patients' daily life. Labosky et al.'s considered a decrease in grip strength of more than 77% and a decrease in pinch strength of more than 33% normal in full radial nerve palsy.[36] The decrease of 14.3% in grip strength and 24% in pinch strength in our series did not seriously affect patients' daily functions. A correlation between an increasing DASH-T score and a loss ratio of pinch and grip strengths was observed. The larger decrease in pinch strength resulted from the innervations of the thenar muscles by the median nerve and a non-fully recovered median nerve. Despite the concomitant vascular and nerve injury in 9 of our patients, measured grip and pinch strengths were sufficient in the overall series.

Possible limitations to this study include the variety of the etiologies of the nerve injuries and the presence of accompanying injuries.

In conclusion, radial nerve repairs, if done end-to-end, using an appropriate technique, may lead to nearly full recovery in younger patients. We suggest nerve repair until the 6th month after the injury using end-to-end anastomosis or grafting methods. If there are no nerve recovery findings following tendon transfer surgery, nerve repair might be considered after a 6 to 8 month period in patients with accompanying injuries, such as median nerve and brachial artery.

**Conflicts of Interest:** No conflicts declared.

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