Sensory Recovery After Forearm Median and Ulnar Nerve Grafting

Reuf Karabeg, Malik Jakirlic, Vanis Dujso
Clinic for Plastic and Reconstructive Surgery, Clinical Center University Of Sarajevo, BiH

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SUMMARY

Background: Median and ulnar nerve injuries are common, whether isolated or combined injury of both nerve. A nerve graft, if performed in a tensionless manner, has been shown to generally have better results than an end-to-end approximation performed under tension. Objective: The aim of this study is to analyze the long-term results of sensory recovery after secondary reconstruction median and ulnar nerve by autograft in patients who were treated on Clinic for Plastic and Reconstructive Surgery in the period from January 1st 1993 to December 31st 2005. We analyzed the influence of the patients age, level of injury, the size of the graft and the period between the injury and operation on the late results. Patients and methods: Evaluation was performed in 55 patients with adequate follow-up. The mean follow-up period was 3,9 years. Reconstructions were applied on the median nerve in 31 patients and ulnar nerve in 24 patients. Criteria for inclusion in the study was median and ulnar nerve grafting in the forearm region. Patients were divided by age in two groups, below 25 and over 25 years, by injury level in the distal and proximal forearm injuries, by the length of autograft up to 5 cm and other group with graft length over 5 cm, by the period between injury and operation in group with denervation time up to 6 months and the group with denervation time over 6 months. Rating of sensibility was presented on the Highet Scale as modified by Dellon and more precise rating of sensibility was presented by Moberg's rating scale of sensibility. Calculation of frequencies and percentual values was performed for all included variables. For establishment of differences between the frequencies the ÷2 – test was used (Chi square test) at the level of statistical importance (p<0,05) with contingency tables . Results: We analyzed the results of reconstruction of median and ulnar nerves with respect to factors affecting functionally the result of operation, which are age, injury level, graft length and denervation time. We had 31 patients with median nerve grafting and we achieved sensory recovery S4 in 3 (10%) patients, S3+ in 9 (29%) patients, S3 in 8 (25,5%) patients, S2 in 9 (29%) patients and S2 in 2 (6,5%) patients. We had 24 patients with ulnar nerve grafting and we achieved S4 sensory recovery in 2 (8,5%) patients, S3+ in 6 (25%) patients, S3 in 5 (21%) patients, S2 in 10 (41%) patients and S2 in 1 (4%) patient. There was not significant difference in sensory recovery of median and ulnar nerve (chi-square = 1.00 ; df = 4; p = 0.909). There was not statistically significant difference by age and level of injury. The results were significantly better in patients with short grafts than in long ones (chi-square = 12.6; df = 4; p = 0.014) and in patients who had undergone surgical repair within 6 months (chi-square = 10; 2 df = 4; p = 0.038). Conclusion: There was not significant difference in sensory recovery of median and ulnar nerves. The graft length and denervation time significantly influenced the functional outcome in sensory recovery. Mechanism of injury impacted on the results. Two point discrimination testing using a paperclip is a cheap, easily and quickly performed reproducible test of tactile gnosis, and should be included in nerve assessment protocols. We recommended using Moberg`s rating scale for further research.

Key words: sensory recovery, median nerve, ulnar nerve, grafting

1. INTRODUCTION

Median and ulnar nerve injuries are common, whether isolated or combined injury of both nerve (1). Especially, ulnar nerve injuries give weaker functional recovery in relation to median and radial nerve injuries (2,3,4,5). Hand function without sensation, especially in the combined injury of both nerve, is significantly reduced (6). Sensory end-organs are less sensitive to denervation than motor end-organs. Recovery of protective sensibility is possible many years after nerve injury but the degree of functional sensation preserved decreases with a delay in nerve repair longer than 6 months (7). In complete lesions of peripheral nerve the best is primary reconstruction (8). A nerve graft, if performed in a tensionless manner, has been shown to generally have better results than an end-to-end approximation performed under tension (9).

2. OBJECTIVES

The aim of this study is to analyze the long-term results of sensory recovery after secondary reconstruction median and ulnar nerve in the forearm by autograft in patients who were treated on Clinic for Plastic and Reconstructive Surgery in the period from January 1st 1993 to December 31st 2005. Also, the purpose of this retrospective study was to determine the influences of the patients age, level of injury, the size of the graft and the period between the injury and operation on the late results.

3. PATIENTS AND METHODS

In study period from 1993 through 2005, evaluation was performed in 55 patients with adequate follow-up. The mean follow-up period was 3,9 years (range, 19 months to 9,6 years). The average patient age was 30.4 years (range, from 6 to 74 years). There were 41 male patients and 14 female patients. Criteria for inclusion in the study was median and ulnar nerve grafting in the forearm region. Reconstruction were applied on the median nerve in 31 patients and ulnar nerve in 24 patients. Patients were divided by age in two groups, below 25 and over 25 years, by injury level in the distal and proximal forearm injuries, by the length of autograft up to 5 cm and other group with graft length over 5 cm, by the period between injury and operation in group with denervation time up to 6 months and the group with denervation time over 6 months. Rating of sensibility was presented on the Highet Scale as modified by Dellon (Table 1) (10). A more precise rating of sensibility was presented by Moberg for the autonomous areas of the median and ulnar nerves (Table 2) (11).

S0	Absence of sensibility in the autonomous area
S1	Recovery of deep cutaneous pain sensibility within the autonomous area of the nerve
S2	Return of some degree of superficial cutaneous pain and tactile sensibility within the autonomous area of the nerve
S3	Return of superficial cutaneous pain and tactile sensibility throughout the autonomous area, with disappearance of any previous overresponse
S3+	Return of sensibility as in S3; in addition, there is some recovery of 2-point discrimination within the autonomous area (7-15 mm)
S4	Complete recovery (2-point discrimination, 2-6 mm)

TABLE 1. Highet's method of end result evaluation as modified by Dellon et all (10)

Grade	*Distance*
Good	<12 mm
Fair	12-15 mm
Poor	16-20 mm
Bad	>20 mm

TABLE 2. Moberg's rating scale of sensibility – median and ulnar sensibility two-point discrimination distance (11)

The analysis applied to those variables are non-parametric statistics. Calculation of frequencies and percentual values was performed for all included variables. For establishment of differences between the frequencies the $\chi 2$ – test was used (Chi square test) at the level of statistical importance ($p<0,05$) with contingency tables .

4. RESULTS

We analyzed the results of reconstruction of median and ulnar nerves with respect to factors affecting functionally the result of operation, which are age, injury level, graft length and denervation time. The results were evaluated using the Highet Scale as modified by Dellon and Moberg's rating scale of sensibility for the autonomous areas of the median and ulnar nerves. Regarding age,

our patients were divided in two groups (<25 years, 22 patients and >25 years, 33 patients). In the first group in three patients (14%) was achieved S4 sensory recovery, S3+ in 8 patients (36%), S3 in 5 patients (23%) and S2 in 6 (27%) of patients. In this group we did not have S0 and S1 sensory recovery. In the age group over 25 years sensory recovery of S4 was obtained in 2 (6%), S3+ in 7 (21%), S3 in 8 (24%), S2 in 13 (40%) and S1 in 3 patients (9%). There was not statistically significant difference in those age groups (p = 0.340).

As shown in table 3, in the group of distal forearm injuries we had 41 patients. In 3 patients (7%) was achived S4 sensory recovery, S3+ in 11 (27%) as well as in S3, S2 in 14 (34%) and S1 in 2 (5%) patients. In the group of proximal forearm injuries we had 14 patients. In 2 patients (14%) was achived S4 sensory recovery as well as in S3, S3+ in 4 (28%), S2 in 5 (36%) and S1 in 1 (7%) patients. There was not statistically significant difference in sensory recovery in those groups (chi-square = 1.37 ; df = 4; p = 0.849).

By the length of the autograft we made two groups, one with up to 5 cm of graft length with 25 patients, and other group with graft length over 5 cm with 30 patients. In the first group in 4 patients (16%) was achieved S4 sensory recovery, S3+ in 10 patients (40%), S3 in 7 patients (28%) and S2 in 4 (16%) of patients. In this group we did not have S0 and S1 sensory recovery. In the group with graft length over 5 cm sensory recovery of S4 was obtained in 1 (3%), S3+ in 5 (17%), S3 in 6 (20%), S2 in 15 (50%) and S1 in 3 patients (10%) (table 3). The results were significantly better in short grafts than in long ones (chi-square = 12.6; df = 4; p = 0.014).

By the period between the injury and operation we also had a two groups, one with denervation time up to 6 months with 36 patients, and the other group with denervation time over 6 months with 19 patients. In the first group 4 patients (11%) had S4 sensory recovery, S3+ had 13 patients (36%), S3 had 10 patients (28%), S2 had 8 (22%) patients and S1 had 1 (3%) patient. In the group with denervation time over 6 months sensory recovery of S4 was obtained in 1 (5%), S3+ in 2 (10,5%), S3 in 3 (16%), S2 in 11 (58%) and S1 in 2 patients (10,5%). Sensory recovery was significantly better in patients who had undergone surgical repair within 6 months (chi-square = 10; 2 df = 4; p = 0.038), compared with patients who underwent reconstruction later than 6 months.

We had 31 patients with median nerve grafting and we achieved sensory recovery S4 in 3 (10%) patients, S3+ in 9 (29%) patients, S3 in 8 (25,5%) patients, S2 in 9 (29%) patients and S2 in 2 (6,5%) patients. We had 24 patients with ulnar nerve grafting and we achieved S4 sensory recovery in 2 (8,5%) patients, S3+ in 6 (25%) patients, S3 in 5 (21%) patients, S2 in 10 (41%) patients and S2 in 1 (4%) patient. We did not have S0 sensory recovery in either case of median and ulnar nerve grafting (Table 4). There was not significant difference in sensory recovery of both nerves (chi-square = 1.00 ; df = 4; p = 0.909).

By Moberg's rating scale of sensibility in the patients with median nerve grafting we had a good results in 8 (26%) patients, fair in 4 (13%), poor in 17 (55%) and bad in 2 (6%) patients. In the patients with ulnar nerve grafting we had a good results in 5 (21%) patients, fair in 3 (13%), poor in 15 (62%) and bad in 1 (4%) patient (Table 5). There was not significant difference in sensory recovery of median and ulnar nerve (chi-square = 0.409; df = 3; p = 0.938).

Sensory recovery	Age		Injury level		Graft lenght		Denervation time	
	< 25 (mean 21,3 years)	>25 (mean 42,1 years)	Distal forearm	Proximal forearm	< 5 cm (mean 3,9 cm)	>5 cm (mean 7,5 cm)	< 6 months (mean 4,3 months)	> 6 months (mean 10,7 months)
S0	-	-	-	-	-	-	-	-
S1	-	3 (9%)	2 (5%)	1 (7%)	-	3 (10%)	1 (3%)	2 (10,5%)
S2	6 (27%)	13 (40%)	14 (34%)	5 (36%)	4 (16%)	15 (50%)	8 (22%)	11 (58%)
S3	5 (23%)	8 (24%)	11 (27%)	2 (14%)	7 (28%)	6 (20%)	10 (28%)	3 (16%)
S3+	8 (36%)	7 (21%)	11 (27%)	4 (28%)	10 (40%)	5 (17%)	13 (36%)	2 (10,5%)
S4	3 (14%)	2 (6%)	3 (7%)	2 (14%)	4 (16%)	1 (3%)	4 (11%)	1 (5%)
Total	22	33	41	14	25	30	36	19

TABLE 3. Sensory recovery (percentage of patients) after complete median and ulnar nerve transection classified by Highet Scale S0-S4 (10)

Grade	S0	S1	S2	S3	S3+	S4
Median nerve	-	2 (6,5%)	9 (29%)	8 (25,5%)	9 (29%)	3 (10%)
Ulnar nerve	-	1 (4%)	10 (41%)	5 (21%)	6 (25%)	2 (8,5%)

Table 4. Sensory recovery after complete median and ulnar nerve grafting classified by Highet Scale (10)

Grade	Bad	Poor	Fair	Good
Median nerve	2 (6%)	17 (55%)	4 (13%)	8 (26%)
Ulnar nerve	1 (4%)	15 (62%)	3 (13%)	5 (21%)

TABLE 5. Sensory recovery after complete median and ulnar nerve grafting classified by Moberg's rating scale (11)

Regarding mechanism of injury, we had an explosive injuries in 17 (31%) patients, machines in 12 (22%) patients and electricity in 4 (7%) patients. Sharp injuries with knife was present in 10 (18%) patients and glass in 12 (22%) of patients (Figure 1.).

5. DISCUSSION

In our study we didn`t found significant difference in sensory recovery after median and ulnar nerve grafting. Generally, it is accepted that ulnar nerve injuries result in poorer motor function than median nerve injuries (2,3,5,12). No significant difference was found in many large studies between median and ulnar nerve injuries regarding sensory recovery (4,5,13). We used Moberg's rating scale of sensibility for more precise rating of sensibility for the autonomous areas of median and ulnar nerves with two-point discrimination distance (11). In Highet`s rating scale and British Medical research Council two point discrimination is present only in S3+ and S4 level of sensory recovery (10,14). Sensibility system adopted by British Research Council and Highet`s scale are inadequate for full sensibility rating. Our opinion is that there should be additional ratings between S3+ and S4. When evaluating nerve function during postoperative follow-up it is imperative to know the sequence of recovery. Using Moberg`s rating scale we wanted to show more precise rating of sensory recovery for the autonomous areas of median and ulnar nerves. The evaluation of touch includes perception of touch and pressure. The two-point discrimination (2PD) is mediated by slowly-adapting nerve fibres that indicate the perception of touch and pressure (6). Tactile gnosis, initially described by Moberg in 1958 as the capability of the hand to recognize the character of objects, is a prime marker of functional recovery and should be included in any testing model (15).

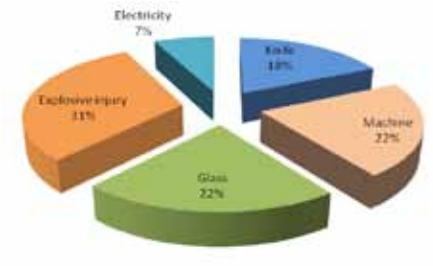

FIGURE 1. Mechanism of injury

Many factors, such a patient age, level of injury, the size of the graft and the period between the injury and operation, have been claimed to influence the prognosis following nerve repair (4,5). The mechanism of injury impacted on the results (5). In our study we had an explosive injuries in 31% patients, machines in 22% of patients and electricity in 7% of patients. Such injuries were extensive with poorly vascularised surrounding tissue and larger nerve defects. Sharp injuries with knife in 18% of patients and glass in 22% of patients were with minimal nerve defect. Most of repairs in those injuries were performed within 6 months, in 19 patients, and better results were obtained.

It is accepted that nerve recovery in younger patients is better than in older patients. Younger patients have better nerve regrowth and greater neural plasticity (4). Some authors reported that better functional recovery can be expected in children younger than 13 years (16). In our research patients younger than 25 years had slightly better results, but not significantly better. The reason for such a results we could found in fact that we had only 5 patients younger than 15 years, and in 4 of them injury was made by glass or knife. The other patients mostly were with nerve reconstruction after war injuries and extensive injuries. Those injuries made by shrapnel, bullet and machine, were extensive with poorly vascularised surrounding tissue. We had 13 patients with such extensive injuries aged 15 to 25 years.

There was not significant difference in the nerve reconstruction by the injury level. Results were similar in both groups. High median and ulnar nerve lesions were reported by other authors to have a very poor prognosis (4,5,17,18). The reason for such results we can found in fact that we analyzed isolated injuries of the proximal and distal forearm, but not the upper arm. Proximal ulnar and median nerve injuries, specially in the upper arm, are distant from motor endplates and sensory receptors, and regenerating fibers have to elongate for a greater distance to reach targets in the hand (17). Most of the injuries were extensive, made by explosion, electricity and machines that extensively destroy tissue (60% of injuries) (Figure 1.). Such injuries required extended graft length, and often were with greater denervation time than 6 months. The group of distal forearm injuries was larger, with 41 of patients. Most of them, 25 patients, had nerve defect larger than 5 cm, and 29 patients from this group were operated after six months from the injury.

We had significantly better results in the patients in which the autograft length was up to 5 cm, and in patients who were operated within six months from the injury. This fact is confirmed in studies by other authors (1,2,4,5,12,19,20). Functional recovery after graft placement depends on the severity of injury and therefore on the graft length (5,12,19,20). We found that worse results correlated with increased graft length and with denervation time over 6 months, like other authors (12,16,17,19,20). Therefore, our results are in correlation with the results of other authors (1,4,12,13,16,17,18,19,20).

6. CONCLUSION

The graft length and denervation time significantly influenced the functional outcome in sensory recovery. Mechanism of injury impacted on the results. Better results were in the patients in which the autograft length was up to 5 cm, and in patients who were operated within six months from the injury. There was not significant difference in sensory recovery of median and ulnar nerves. Two point discrimination testing using a paperclip is a cheap, easily and quickly performed reproducible test of tactile gnosis, and should be included in nerve assessment protocols. There should be additional ratings between S3+ and S4 in British Research Council scale and Highet`s scale for more precise rating of sensory recovery. When evaluating nerve function during postoperative follow-up it is imperative to know the sequence of recovery. Therefore, we recommended using Moberg`s rating scale for further research. With these scales and tests it is possible for physicians who evaluate nerve repairs to assess functional recovery.

REFERENCES

1. Kouyoumdjian J A. Peripheral nerve injuries: A retrospective survey of 456 cases. Muscle Nerve, 2006; 34: 785.
2. Allan CH, Vanderhooft E. Functional outcomes after nerve grafting. Atlas Hand Clin, 2005; 10: 93.
3. Bruyns CN, Jaquet JB, Schreuders TA, Kalmijn S, Kuypers PD, Hovius SE. Predictors for return to work in patients with median and ulnar nerve injuries. J Hand Surg (Am.), 2003; 28: 28.
4. Vordemvenne T, Langer M, Ochman S, Raschke M, Schult M. Long-term results after primary microsurgical repair of ulnar and median nerve injuries: A comparison of common score systems. Clin Neurol Neurosurg, 2007; 109: 263.
5. Ruijs AC, Jaquet JB, Kalmijn S, Giele H, Hovius SE. Median and ulnar nerve injuries: A meta-analysis of predictors of motor and sensory recovery after modern microsurgical nerve repair. Plast Reconstr Surg, 2005; 116: 484.
6. Dellon AL, Curtis RM, Edgerton MT. Reeducation of sensation in the hand after injury and repair. Plast Reconstr Surg, 1974; 53: 297.
7. Flores AJ, Lavernia CJ, Owens PW: Anatomy and physiology of peripheral nerve injury and repair. Am J Orthop, 2000; 29:167-73.
8. Birch R, Raji ARM. Repair of median and ulnar nerves. Primary suture is best. J Bone Joint Surg, 1991; 73B:154–7.
9. Millesi H. Techniques for nerve grafting. Hand Clin, 2000; 16: 73-91.
10. Dellon AL, Curtis RM, Edgerton MT. Reeducation of sensation in the hand after nerve injury and repair. Plast Reconstr Surg, 1974; 53:297-305.
11. Moberg E. Criticism and study of methods for examining sensibility in the hand. Neurology, 1962; 12: 8-19.
12. Kabak S, HaliciM, Baktir A, Turk C, Avsarogullari L. Results of treatment of the extensive volar wrist lacerations: 'the spaghetti wrist'. Eur J Emerg Med, 2002; 9(1): 71–6.
13. Roganovic Z, Pavlicevic G. Difference in recovery potential of peripheral nerves after graft repairs. Neurosurgery, 2006; 59: 621.
14. Seddon HJ. Surgical disorders of the Peripheral Nerves, 2nd ed. Edinburgh, Churchill Livingstone, 1975.
15. Moberg E. The unsolved problem: how to test the functional value of hand sensibility. J Hand Ther, 1991; 4: 105–10.
16. Bolitho DG, Boustred M, Hudson DA, Hodgetts KA. Primary epineural repair of the ulnar nerve in children. J Hand Surg (Am.), 1999; 24: 16.
17. Battiston B, Lanzetta M. Reconstruction of high ulnar nerve lesions by distal double-median to ulnar nerve transfer. J Hand Surg (Am.), 1999; 24: 1185.
18. Kim DH, Han K, Tiel R L, Murovic JA., Kline DG. Surgical outcomes of 654 ulnar nerve lesions. J Neurosurg, 2003; 98: 993.
19. Roganovic Z. Missile-caused ulnar nerve injuries: Outcomes of 128 repairs. Neurosurgery, 2004; 55: 1120.
20. Daneyemez M, Solmaz I, Izci Y. Prognostic factors for the surgical management of peripheral nerve lesions. Tohoku J Exp Med, 2005; 205:269–75.

Corresponding author: Reuf Karabeg, MD, PhD. Clinic for Plastic Surgery. Clinical center of Sarajevo University. Tel.: 00 387 33 297 000.