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Immediate Tendon Transfer with Nerve Repair in Low Combined Ulnar and Median Nerve Injury

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Background: Combined median-ulnar nerve injury at the level of distal forearm (below the musculotendinous junction) causes a detrimental effect on hand functions, which have a great impact on patients' hands as well as a financial burden. Many previous authors advocated early or immediate tendon transfer in solitary median or ulnar nerve injuries.

Methods: This study included 20 patients with combined distal ulnar-median nerve injury, who were divided into 2 groups. Group I (control) included 10 patients who underwent primary (group fascicular) repair of both nerves only. Group II (study) included 10 patients underwent primary (group fascicular) repair with immediate tendon transfer simultaneously: opponenplasty using extensor indicies and adductoplasty extensor carpi radialis brevis with appropriate splinting, postoperative rehabilitation, and biofeedback facilities.

Results: Twenty patients (age: 18–38 years) were affected. The response of median and ulnar nerves showed invariable results in both groups, whilst the hand grip, hand pinch, and opposition showed marked improvements in group II. Moreover, inter-phalangeal and metacarpophalangeal joints of thumb showed no deformities in group II in comparison with high level of deformities in group I, owing to early regain of thumb movements.

Conclusions: Immediate (during neurorrhaphy) tendon transfer may offer additional merits over nerve repair only for distal combined ulnar and median injury, as it offers scarless field, no adhesion, and no joint edema, leading to very early return to normal hand functions with a consequent decrease of thumb deformities, better hand grip, and key pinch. *(Plast Reconstr Surg Glob Open 2021;9:e3597; doi: 10.1097/GOX.0000000000003597; Published online 27 May 2021.)*

INTRODUCTION

Distal combined median and ulnar nerve injuries (below the musculotendinous junction of long flexors in distal forearm) are rather uncommon injuries; however, they carry a dramatic loss of hand function if affecting the dominant hand. These injuries are more common in manual workers than in others. Ulnar nerve injuries alone are the most common in peripheral nerve injuries (3.86 per 100,000) followed by median nerve alone (2.01 per 100,000) in a study conducted in 2019 by Tapp et al. This study reported the epidemiology of upper extremity nerve injuries and the associated cost in the United States emergency departments.[1] Treatment of these nerve injuries often requires meticulous group fascicular repair, with identification of motor and sensory nerve fascicles topographically.[2] The time for regaining function depends on the location of injury: along the axons, at which proximal segment regenerates at a rate of 1 mm/day,[3] which may be accelerated by growth hormones[4] or electric stimulation.[5] Combined median and ulnar nerve injuries greatly affect hand functions, particularly in the thumb, where they can cause thumb deformities in the form of external rotation, hyperextension of the metacarpophalangeal joint, and flexion of interphalangeal joint. These alterations are attributable to denervation of the adductor pollicis, flexor pollicis brevis (and the loss of their metacarpophalangeal joint stabilizing effects), and opponens pollicis, leading to external rotation. The force of the flexor pollicis longus

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leads to significant IP flexion with attempted pinch. Over time, the loss of metacarpophalangeal dynamic stabilizers leads to metacarpophalangeal volar plate laxity and metacarpophalangeal hyperextension followed by compensatory interphalangeal flexion deformity.[6,7]

In 1989, Abreu proposed immediate tendon transfer (adductoplasty) during nerve repair of ulnar nerve injuries, and found that restoration of pinch may be achieved within 3 or 4 weeks by a 1-stage operation combining nerve repair and tendon transfer. He used this approach for nerve injuries of the upper limb since his early work from the year 1961. The results were excellent.[8]

Despite moderate to good results in patients who have had group fascicular repair to distal ulnar and median nerve injuries, there is still a need to decrease postoperative recovery time, especially with manual workers; also, adhesions and joint edema may jeopardize the results. Consequently, we proposed that immediate tendon transfer for thumb opposition and adduction (at the time of ulnar and median nerve repair) may offer additional merits over group fasicular repair only, as it offers scarless field, no adhesion, and no joint edema. Moreover, the recovery time may be decreased to 5 weeks.

PATIENTS AND METHODS

This study is a prospective randomized controlled clinical trial, conducted from March 2019 to November 2020. It involved 20 patients with combined distal (below the musculotendinous junction) ulnar-median nerve injury, with age ranging from 16 to 40 years. Institutional review board approval was obtained before any intervention. Informed consent from patients has been obtained after providing them with comprehensive details of the operations, results, expected outcome, and complications. Patients were divided randomly (using every other patient pattern for randomization, with no selection of any difference between candidates in each group) into 2 equal groups: group I involved patients who underwent primary group fascicular repair only; group II involved patients who underwent primary group fascicular repair and, in addition, immediate tendon transfer in the form of opponenplasty (using extensor indicies),[9] and adductoplasty (using extensor carpi radialis brevis).[10,11] Patients with concomitant systemic illness such as diabetes, rheumatoid, neurologic diseases, renal and hepatic were excluded. Patients with previous hand trauma, particularly radial nerve or any extensor compartment injury were also excluded.

All patients received the same postoperative rehabilitation whether in nerve repair only (group I) or in combination with tendon transfer (group II) in the form of appropriate protective splinting to promote healing and to elude median and ulnar nerve deformities. Electric stimulation of small hand muscles in both groups was done regularly. In addition, biofeedback was done in the tendon transfer group to assist retraining.[12] Biofeedback measures specific function or certain types of activity and feeds them back to the patient to increase awareness and control over biological processes.[13] In our case, the biofeedback was to re-orient the brain after tendon transfer.

Postoperative assessments at 3- and 6-month intervals were done in 3 different ways. The first method involved assessment of powerful hand grip and key pinch by a dynamometer. The second one included nerve conduction velocity and electromyophysiology for both ulnar and median nerves and comparing them with those of the other healthy side. Fortunately, all patients had no prior injuries in the other upper limb. The nerve conduction was considered “no response” if the amplitude of the nerve conduction is zero, “partial response” if less than half the amplitude of the same nerve on the other side, and “complete recovery” if the amplitude of the conduction is within the same range or near to the other side. The third method of assessment was documentation of any thumb deformities by means of a goniometer. Thumb deformities assessed were external rotation of the thumb at the level of the basal joint and flexion deformity of the interphalangeal joint of the thumb. All data were collected, revised, coded, and entered into SPSS (IBM SPSS statistics, version 23). Quantitative variables were presented as mean, SD, and range, whereas qualitative variables were presented as number and percentage. Chi-square test was used to compare qualitative variables between groups. Paired *t*-test was used to compare 2 paired groups with regard to the quantitative variables with parametric distribution, whereas with non-parametric distribution, Wilcoxon rank test was used. Independent *t*-test was used to compare 2 groups with regard to the quantitative variables with parametric distribution, while with non-parametric distribution, Mann-Whitney test was used. The confidence interval was set to 95%. The mean value was considered significant at $P < 0.05$, non-significant at $P > 0.05$, and highly significant at $P < 0.01$.

RESULTS

The patient population included 17 men and 3 women (age: 18–38 years). Group I included 8 men and 2 women with a mean age of 26.40 ± 5.68 years. Group II included 9 men and 1 woman with mean age of 24.60 ± 4.84 years. Occupations included predominantly manual workers (65%). There were no statistical differences between age, gender, job title, or hand dominance in the 2 groups. Mode of trauma was due to sharp injury by knife in 13 patients and electric saw in 7 patients, with no statistical difference between 2 groups concerning mode of trauma. The injury site was measured from the wrist crease and documented ranging from 2 to 11 cm from the wrist crease in both groups with no statistically significant differences. The extent of the injury was localized to the trauma site with no further extension (Table 1). All patients were operated upon within 24 hours. All employed patients were encouraged to return to normal life activities after the period of immobilization and early physical rehabilitation in average after 3 months. All patients suffered concomitant flexors injuries which were repaired at the same time as nerve repair and tendon transfer. Assessment after the first 3 months included nerve conduction velocity and electromyography (EMG) examination, which showed no response in median and ulnar nerves for all cases except 2 cases, which showed partial response. However, the assessment of hand grip by dynamometer showed higher results in group II (21.80 ± 11.65) than in group I (7.50 ± 9.03), which was highly significant statistically. Moreover, hand pinch assessment showed higher results in group II (10.70 ± 2.67) than in group I (5.70 ± 3.59) that was highly significant statistically. The assessment of thumb opposition revealed marked results in group II (52.90 ± 11.35) than in group I (0.60 ± 1.26) as measured by Goniometer, that was highly significant. In addition, proximal interphalangeal joint flexion deformity was higher in group I than in group II, and that was highly significant. Metacarpophalangeal joint deformity in group I was higher than in group II as well, and that was also highly significant (Table 2). (**See Video [online],** which demonstrates a 37-year-old male patient with combined median and ulnar nerves at 5 cms above the distal crease. He underwent nerve repair with immediate tendon transfer (group II). This video is taken after only 3 months displaying nearly full thumb adduction and opposition.).

Assessment 6 months postoperatively with nerve conduction velocity and electromyography (EMG) showed complete response only in 2 patients, and partial response in 12 patients. The difference between the 2 groups was not significant. Both hand grip and hand pinch showed better improvement in group II (31.20 ± 7.69, 13.30 ± 2.54) than in group I (19.20 ± 14.82, 9.10 ± 3.90) respectively, and that was significant statistically. In addition, thumb opposition showed a more marked improvement in group II (49.30 ± 3.09) than in group I (19.40 ± 6.08), and that was highly significant. Both proximal interphalangeal and metacarpal phalangeal joint deformities showed better results in group II than in group I, and that was highly significant (Table 3).

DISCUSSION

Combined median and ulnar distal forearm injuries are rather uncommon, but they lead to a major loss of affected hand functions, with loss of the key pinch and opposition of the thumb with weaker hand grip, thumb basal joint instability, and hand deformities. Despite progress in techniques of nerve repair and high magnification, complete regaining of function seldom occurs. Moreover, the time consumed to regain these functions may extend to several months. Even scarring after the repair may compromise the joint movements later on. Thus, many authors mandate immediate or early tendon transfer in solitary ulnar or median nerve injuries to avoid these drawbacks.[8–12,14,15]

In this study, 20 patients suffering from combined distal median and ulnar nerve injuries were divided into 2 equal groups. Group I (control) had primary (group fascicular) repair only. Group II (study) had primary (group fascicular) repair and, in addition, immediate tendon transfer in form of opponenplasty (using extensor indicies proprius) and adductoplasty (using extensor carpi radialis brevis). All patients received postoperative rehabilitation according to their operation whether in nerve repair only or in combination with tendon transfer with appropriate splinting to promote healing and avoid median and ulnar nerve deformities as claw hand. Assessment of hand functions as powerful hand grip and hand pinch was assessed by a dynamometer in all patients after 3 and 6 months. Nerve conduction velocity and electromyophysiology was done to all patients at 3 and 6 months after nerve repair. Any interphalangeal or metacarpophalangeal joint deformities in the thumb were measured using a goniometer and recorded. No modifications to the tendon transfer techniques were done in this study, but only to the timing, as previously described.

The results were promising: both groups showed insignificant difference concerning the nerve conduction velocity and the electromyophysiology. However, hand functions and incidence of joint deformities showed valuable differences. Hand grip showed a highly significant

Table 1. Comparison between 2 Groups on Age, Gender, Job Title, and Hand Dominance

		Control Nerve Repair Group (N = 10)	Nerve and Tendon Transfer Group (N = 10)	Test Value	*P*	Sig.
Age	Mean ± SD	26.40 ± 5.68	24.60 ± 4.84	0.763†	0.455	NS
	Range	19 – 38	18 – 33			
Gender	Women	2 (20.0%)	1 (10.0%)	0.392*	0.531	NS
	Men	8 (80.0%)	9 (90.0%)			
Job title	Manual worker	7 (70.0%)	6 (60.0%)	4.410*	0.492	NS
	Student	1 (10.0%)	2 (20.0%)			
	Packer	1 (10.0%)	0 (0.0%)			
	Housewife	1 (10.0%)	0 (0.0%)			
	Writer	0 (0.0%)	1 (10.0%)			
	Butcher	0 (0.0%)	1 (10.0%)			
Hand dominance	Right	8 (80.0%)	9 (90.0%)	0.392*	0.531	NS
	Left	2 (20.0%)	1 (10.0%)			
Distance of injury from wrist crease	Mean ± SD	5.59±2.98	5.7±3.59	0.075	0.941	NS
	Range	2–11	2–11			
Mechanism of injury	Knife	6	7			NS
	Electric saw	4	3			
No. flexors lacerated	All flexor compartment	10	10			NS

*Chi-square test.

Distance of forearm injury to wrist crease, mode of trauma, and number of flexor tendons were also compared. $P > 0.05$: nonsignificant; $P < 0.05$: significant; $P < 0.01$: highly significant.

Table 2. Comparison of the 3 Methods of Assessment between the 2 Groups after 3 Months

Three-month Nerve Conduction and EMG		Control Nerve Repair Group Group I (N = 10)	Nerve and Tendon Transfer Group Group II (N = 10)	Test Value	*P*	Sig.
Result median	No response	10 (100.0%)	10 (100.0%)	—	—	—
	Partial response	0 (0.0%)	0 (0.0%)			
	Complete response	0 (0.0%)	0 (0.0%)			
Result ulnar	No response	8 (80.0%)	10 (100.0%)	2.222*	0.136	NS
	Partial response	2 (20.0%)	0 (0.0%)			
	Complete response	0 (0.0%)	0 (0.0%)			
Dynamometer						
Hand grip (patient)	Mean ± SD	7.50 ± 9.03	21.80 ± 11.65	−2.721†	0.007	HS
	Range	2–25	10–40			
Hand pinch (patient)	Mean ± SD	5.70 ± 3.59	10.70 ± 2.67	−2.500†	0.012	S
	Range	2–11	5–15			
Goniometer						
Opposition (patient)	Mean ± SD	0.60 ± 1.26	52.90 ± 11.35	−14.485‡	0.000	HS
	Range	0–3	45–84			
IP deformity (patient)	Mean ± SD	89.10 ± 3.35	0.00 ± 0.00	84.150‡	0.000	HS
	Range	80 – 92	0–0			
MCP deformity (patient)	Mean ± SD	40.50 ± 7.98	0.00 ± 0.00	16.058‡	0.000	HS

*Chi-square test.
†Mann-Whitney test.
‡Independent *t*-test.
IP, interphalangeal joint; MCP, metacarpophalangeal joint. $P > 0.05$: nonsignificant (NS); $P < 0.05$: Significant; $P < 0.01$: Highly significant (HS).

Table 3. Comparison of the 3 Methods of Assessment between the 2 Groups after 6 Months

Six-month NCV and EMG		Control Nerve Repair Group Group I (N = 10)	Nerve and Tendon Transfer Group Group II (N = 10)	Test Value	*P*	Sig.
Result median	No response	6 (60.0%)	7 (70.0%)	0.220*	0.639	NS
	Partial response	4 (40.0%)	3 (30.0%)			
	Complete response	0 (0.0%)	0 (0.0%)			
Result ulnar	No response	7 (70.0%)	6 (60.0%)	3.8770*	0.144	NS
	Partial response	1 (10.0%)	4 (40.0%)			
	Complete response	2 (20.0%)	0 (0.0%)			
Dynamometer						
Hand grip (patient)	Mean ± SD	19.20 ± 14.82	31.20 ± 7.69	−2.098†	0.036	S
	Range	5–40	25 – 43			
Hand pinch (patient)	Mean ± SD	9.10 ± 3.90	13.30 ± 2.54	−2.173†	0.030	S
	Range	4–14	10 – 18			
Goniometer						
Opposition (patient)	Mean ± SD	19.40 ± 6.08	49.30 ± 3.09	−13.866‡	0.000	HS
	Range	14–30	45 – 55			
IP deformity (patient)	Mean ± SD	28.50 ± 10.55	0.00 ± 0.00	8.539‡	0.000	HS
	Range	10–45	0 – 0			
MCP deformity (patient)	Mean ± SD	26.50 ± 11.07	0.00 ± 0.00	7.571‡	0.000	HS

*Chi-square test.
†Mann-Whitney test.
‡Independent *t*-test.
IP, interphalangeal joint; MCP, Metacarpophalangeal joint. $P > 0.05$: nonsignificant (NS); $P < 0.05$: significant (S); $P < 0.01$: highly significant (HS).

increase in group II at 3 and 6 months postoperatively; also, the key pinch showed a more dramatic improvement in group II than in group I. Opposition itself as a separate movement of the thumb showed valuable improvement in group II; moreover, group I patients did not show any opposition movement at 3-month evaluation and showed moderate results at 6 months. In contrast, group II showed normal thumb opposition as early as 3 months postoperatively.

The main impact of this transfer gratified the interphalangeal and metacarpophalangeal joints of the thumb. This led to zero incidence of joint deformities or contractures, and, later on, to internal splinting effect of the transferred tendons, leading to more stability of the metacarpophalangeal joint. This could be explained also by the ability of early motion, aggressive physiotherapy and rehabilitation, early brain orientation following the transfer, with nearly scarless field and enthusiastic patients after seeing immediate results following the operations.

Limitations of this study were that the operations were lengthier than usual (adding, on average, 60 minutes to the original operation) and the need for expert senior hand surgeon on call, as the injuries may have affected radial ± ulnar arteries and, therefore, need immediate repair. Need for tendon grafting to lengthen the extensor carpi radialis brevis was satisfied by the palmaris tendon; however, in 3 patients plantaris graft was taken owing to the absence of palmaris. Furthermore, short follow-up time is another limitation. Although most patients were followed up for 18 months postoperatively, 25% of the patients were followed up for a shorter period, which made long-term results unobtainable in order to compare between both groups. This issue may be solved by calculating the time needed for the regeneration process. The nerves usually proceed along the neural tube to reconstitute the axon at a rate between 1 and 4 mm per day.[16] So, given that the longest distance from the distal crease in our study was 11 cm, leading to about 110 days in the highest consideration. Moreover, addition of 4 cm from the wrist crease to the base of muscles consumes another 40 days. Additional 30 days are needed for Wallerian degeneration, leading to a sum of 180 days. This time may be sufficient in nearly all cases to get a good response. That evidence may be contradictory to some cases in other studies that followed up patients for many years; so, still this is a limitation in our study and all the patients should have been followed for at least 1 year.

CONCLUSIONS

Combination of nerve repair and immediate tendon transfer may have a good impact on patients with ulnar and median nerve injuries, with early return to their normal life and better hand functions. Addition of immediate tendon transfer to nerve repair may be better than early transfer after 3 or 6 months, as it offers scarless field, no adhesion, no joint edema, and the same time consumed for immobilization after nerve and tendon repair is only performed once.

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