Transfer of sensibility in the hand: A new method to restore sensibility in ulnar nerve palsy with use of microsurgical digital nerve translocation

We describe a technique of translocation of a functioning proximal digital nerve into a nonfunctional distal digital nerve. Seventeen cases of digital nerve translocation have been done, thirteen were done for treatment of ulnar nerve palsy. Three patients were less than six months after operation and one had died, leaving thirteen available for follow-up. The average length of follow-up is seventy-eight months. Outcome was assessed objectively by functional sensory testing and subjectively by questionnaire. Ten (85%) of twelve of those tested had return of two-point discrimination. In all cases proprioception and protective sensibility were restored to the affected digit. (J Hand Surg 1991;16A:219-26.)

Gregory W. Stocks, MD, Tyson Cobb, BS, *and* Royce C. Lewis, Jr., MD, *Lubbock, Texas*

Despite the many effective methods to restore motor function in ulnar nerve palsy, there currently is not a reliable, simple method to restore sensibility. Loss of protective sensibility to the important ulnar border of the hand and loss of proprioception to the small finger imparts a significant functional limitation to the hand. Free nerve grafting and free neurovascular cutaneous island flap on a very long pedicle are technically demanding procedures that have been used with success in certain circumstances.[1] Digital nerve translocation is a relatively simple method to restore sensibility in the hand. For treatment of ulnar nerve palsy, the procedure entails the translocation of a functioning digital nerve of median origin into the nonfunctional ulnar digital nerve of the small finger. Digital nerve translocation can also improve hand function by transfer of useful sensibility for other types of nerve injury.

From the Hand Surgery Service, Texas Tech University Health Science Center and University Medical Center, Lubbock, Texas.

Received for publication March 22, 1990; accepted in revised form June 8, 1990.

No benefits in any form have been received or will be received from a commercial party related directly or indirectly to the subject of this article.

Reprint requests: Royce C. Lewis, Jr., MD, 3502 9th St., Suite G10, Lubbock, TX 79415-3300.

3/1/23858

There has been sparse interest reflected in the literature on the translocation of normal nerves to regain sensibility. The first report of cross reinnervation to restore sensibility was in 1921 by Harris[2] who transferred the superficial radial nerve into the distal portion of the median nerve in a soldier with irreparable segmental loss. The patient regained sensibility in the entire median nerve distribution, with the exception of an area on the tip of the index finger. In 1946, Sadr[3] reported the case of a musician who sustained a severe laceration to his forearm with inadvertent repair of the proximal median nerve to the distal ulnar nerve and subsequent repair of the proximal ulnar nerve to the distal median nerve. The patient regained two-point discrimination and some motor function. Turnbull[4] in 1948 reported return of "crude" sensibility after translocation of the superficial radial nerve to the median nerve in four soldiers. He noted that maximal sensory return did not occur for several years. Hara and associates[5] have reported return of sensibility with the same nerve transfer. In 1977, Chacha and colleagues[6] reported the results of cross reinnervation in six monkeys. Two monkeys had transfer of the superficial radial nerve, two had the dorsal ulnar sensory transferred, and two had both nerves transferred into the distal portion of the transected median nerve. Reinnervation was confirmed by histologic and histochemical reactions in the Meissner's corpuscles; it was believed to have occurred, at least in the two monkeys that had both nerves transferred.

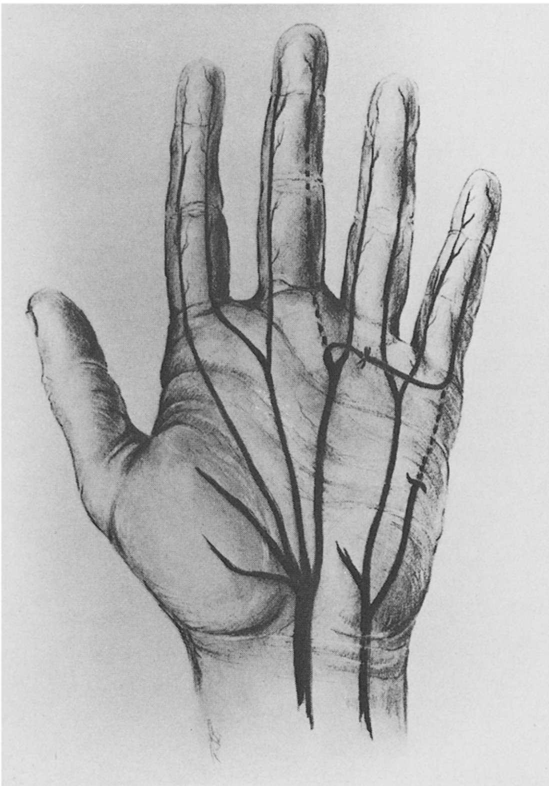

Fig. 1. Translocation of the ulnar digital nerve from the long finger (of median origin) into the ulnar digital nerve of the small finger. This is the standard transfer for ulnar nerve palsy, performed in 12 patients. Table IV details the results. (Reprinted with permission from Lewis RC, Tenny JR, Irvine D. The restoration of sensibility by nerve translocation. Bull Hosp Jt Dis Orthop Inst 1984;44(2):288-96.)

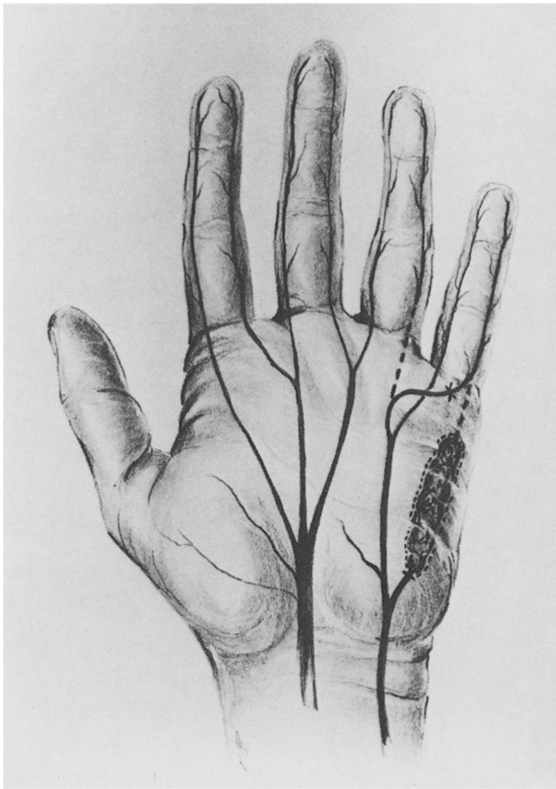

Fig. 2. Transfer of ulnar digital nerve from the ring finger to the ulnar digital nerve of the small finger in a 13-year-old with recurrent neurofibromas of the ulnar digital nerve to small finger in the palm. In 1964 this was the first digital nerve translocation done by the senior author. The patient had return of normal sensibility to the small finger. (Reprinted with permission from Lewis FR, Tenny JR, Irvine D. The restoration of sensibility by nerve translocation. Bull Hosp Jt Dis Orthop Inst 1984;44(2):288-96.)

This article reports the long-term follow-up of 13 cases of digital nerve translocation to restore sensibility to the hand. In most cases this was the transfer of the median derived ulnar digital nerve from the long finger into the ulnar digital nerve of the small finger in patients with ulnar nerve palsy. Several other types of digital nerve translocations done in special situations are also reported. This technique was devised by the senior author (R. C. L.) and has been successful to the extent that it has become a part of the standard reconstructive procedure for patients with an ulnar nerve palsy.

Materials and methods

The senior author has done 17 digital nerve translocations between February 1964 and May 1989. The indication for surgery was low ulnar nerve palsy as a result of injury in 12 patients, irreparable high ulnar nerve injury in 1 patient, irreparable low median nerve injury in 2 patients, irreparable common digital nerve injury in 1 patient because of injury, and in 1 patient as a result of recurrent neurofibromas. The standard translocation used in ulnar nerve palsy is illustrated in Fig. 1. The various other types of digital nerve translocations that have been done are shown in Figs. 2 through 6. The first five cases were reported by the senior author in 1984.[7] These patients were reexamined and are included in this report. This report is based on the 13 patients who are alive at least 6 months after the operation. Three patients are less than 6 months after the operation, but all have shown some return of sensibility in the small finger. The one patient lost to follow-up was a 60-year-old man who died at 5 months after the transfer. Examination at his last office visit

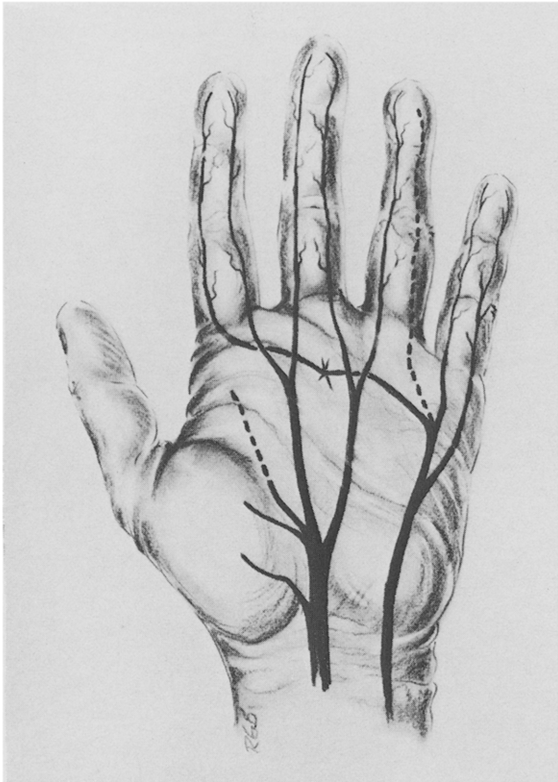

Fig. 3. Transfer of the ulnar digital nerve from the ring finger to the radial digital nerve of the index finger in a 34-year-old who had residual sensory loss in the index finger after sural nerve grafting of the median nerve for treatment of segmental loss. The operation was done 19 months after the injury. Follow-up 10 months after translocation revealed return of gross sensibility without two-point discrimination.

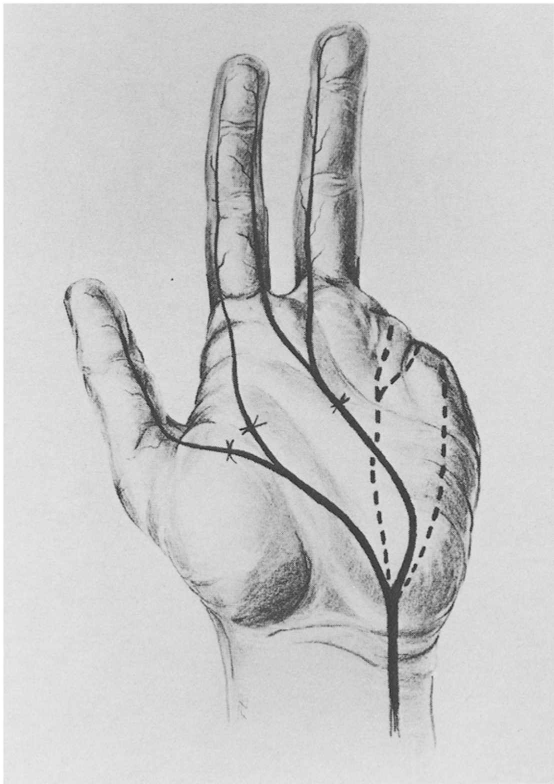

Fig. 4. Multiple nerve transfers in a 23-year-old with loss of the ring and small fingers and a segment of the median nerve. At follow-up 101 months later this patient had return of two-point discrimination in the thumb, index, and long fingers. (Reprinted with permission from Lewis RC, Tenny JR, Irvine D. The restoration of sensibility by nerve translocation. Bull Hosp Jt Dis Orthop Inst 1984;44(2):288-96.)

revealed that he already had return of proprioception and protective sensibility. Of the remaining 13 patients, 12 returned for examination, and all responded to a questionnaire.

Surgical technique

Translocation of the ulnar digital nerve from the long finger to the ulnar digital nerve of the small finger, the standard operation for ulnar nerve palsy, is described to illustrate the operative technique. A volar zigzag incision is used to expose the ulnar digital nerve of the long finger. With the aid of magnification, the dissection is carried distally to the distal interphalangeal (DIP) joint, where the digital nerve trifurcates, and proximally 2 to 3 cm into the palm. The digital nerve is freed throughout its length. A second flap incision is made at the distal palmar flexion crease in the ring and small finger web space. The ulnar branch of the common digital nerve to the small finger is identified and the proximal aspect is dissected free. The ulnar digital nerve to the long finger is cut at the DIP joint level and passed subcutaneously into the ulnar incision. The nerve is passed superficial to the flexor tendons to the ring finger, and care is taken to ensure that there is sufficient soft tissue protection both palmar and dorsal to the nerve. The ulnar digital nerve to the small finger is cut as proximally as possible. The nerves are sutured together with use of microsurgical technique with 10-0 nylon. The nerve translocation is usually done at the same time as the tendon transfers for ulnar nerve palsy and adds approximately 20 minutes to the operative time.

Functional sensory recovery was evaluated objectively using the eight tests described by Tenny and

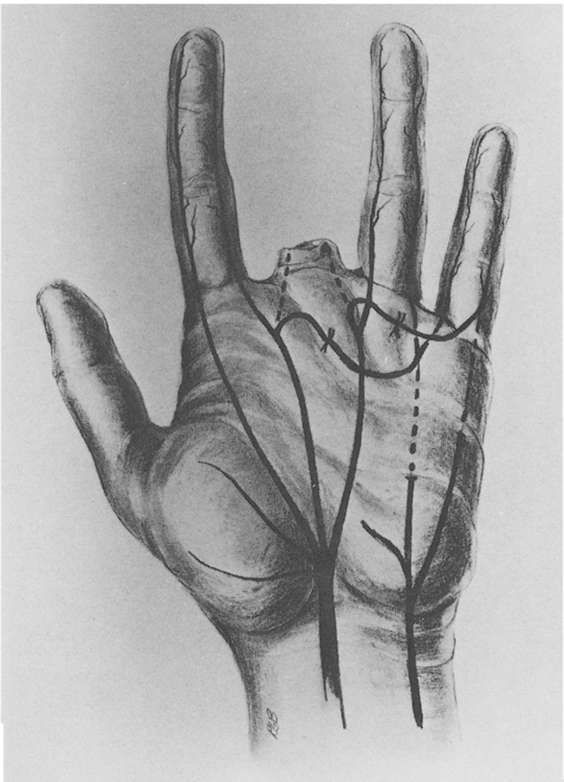

Fig. 5. Nerve transfers in a 33-year-old with massive segmental loss of the ulnar nerve in the forearm and amputation of the long finger. A resection of the third ray was done at the time of nerve transfer. The operation was done 120 months after the original injury. Follow-up 96 months later revealed two-point discrimination and proprioception in the small finger. (Reprinted with permission from Lewis RC, Tenny JR, Irvine D. The restoration of sensibility by nerve translocation. Bull Hosp JT Dis Orthop Inst 1984;44(2):288-96.)

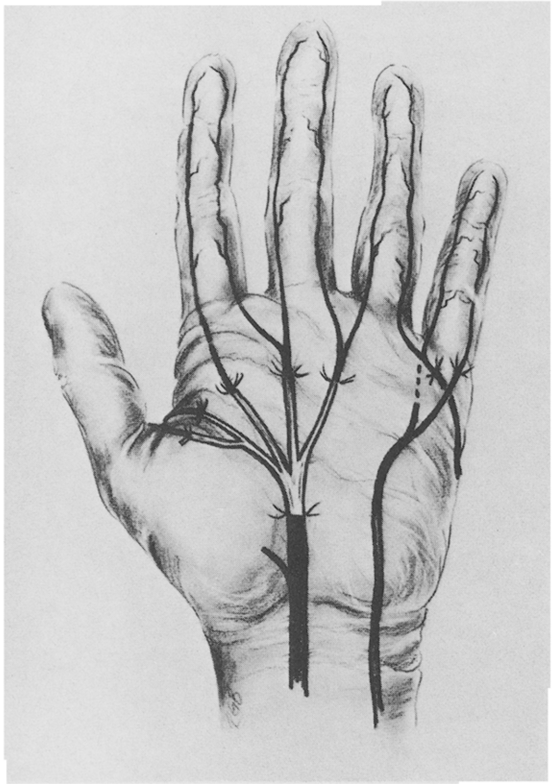

Fig. 6. Transfer of the dorsal ulnar cutaneous nerve to the common digital nerve of the ring and small finger in a 19-year-old who sustained a severe table saw injury to the palm severing all branches of the median and ulnar nerves. Primary repair of the ulnar digital nerve to the small finger and cable nerve grafts of the median nerve had been done previously but with little return of sensibility to the small finger.

Lewis[8] to calculate a functional sensory recovery (FSR) score (Table I). The FSR score is based on a 100-point scale, and outcome was graded excellent for a score of 100 to 80, good for 79 to 60, fair for 59 to 50, and poor for less than 50. The sensory nerve function was also determined, according to the British Medical Research Council (BMRC) standards for comparison with other techniques (Table II). Subjective outcome was assessed by a questionnaire consisting of six questions; it was scored on a scale of 100 points assigned according to the relative importance of each question (Table III). A score of 100 to 80 was considered excellent, 79 to 60 good, 59 to 50 fair, and less than 50 poor.

Results

The results are summarized in Table IV. The average length of follow-up for the 13 patients is 78 months. Functional sensory testing revealed 91% good and excellent results and 8% fair with no poor outcome. According to the BMRC scale for evaluation of sensory recovery, 10 (85%) of 12 were at the S3+ or S4 level, indicating return of two-point discrimination.

Subjectively, 11 (85%) of 13 patients had good or excellent results and 2 patients had a poor outcome. Of the two patients with a poor subjective outcome, one had discontinued her rehabilitation and given up use of the hand because of other severe injuries. The other patient had stopped working completely and was receiving disability compensation, although his injury was to his nondominant hand. He did have protective sensibility and proprioception and did use the hand while not being tested.

There were no surgical complications related to the procedure. Three of the patients perceived a significant amount of the sensibility in the small finger as coming from the donor finger. It was observed that the patients who frequently used the hand with the nerve translo-

Table I. Functional sensory recovery (FSR)

Test	*Partial points for each test*	*Total points for each test*	*Average score*
1. Sharp verses dull discrimination		15	14
2. Temperature			
Hot (approximately 100° F)	7.5		
Cold (approximately 32° F)	7.5	15	14
3. Vibration with tuning fork			
30 cps	5		
256 cps	5	10	9
4. Moving touch			
Single point	5		
Two points between 10 mm and 20 mm	2.5		
Two points less than 10 mm	5	10	9
5. Static two-point discrimination			
Between 10 mm and 20 mm	5		
Less than 10 mm	10	10	7
6. Thickness			
Distinguishing between blocks 1 cm, 2 cm, and 3 cm thick			
Two blocks	5		
Three blocks	10	10	6
7. Texture			
Differentiation between canvas cloth, Velcro, and medium grade sandpaper			
Any two	10		
All three	15	15	14
8. Shape			
Differentiation between four objects: 5 mm diameter cylinders 1 mm and 4 mm thick and 5 mm rectangles 1 mm and 4 mm thick			
Any two	5		
Any three	10		
All four	15	15	10

Average score based on 12 patients examined.

Table II. BMRC grading of sensory recovery in the autonomous area of a nerve (Zachary 1954)[9]

S0	Absence of any sensory recovery
S1	Recovery of deep cutaneous pain sensibility
S2	Return of some superficial pain and tactile sensibility
S2+	Recovery of touch and pain sensibility throughout the autonomous zone but with persistent over-reaction
S3	Return of superficial pain and tactile sensibility throughout the autonomous zone with disappearance of over-reaction
S3+	As S3 but with good localization and some return of two-point discrimination
S4	Return of sensibility as in S3, with recovery of two-point discrimination

cation and those who worked faithfully at sensory rehabilitation had better localization of sensory stimulus.

Discussion

The loss of sensibility in ulnar nerve palsy remains a significant obstacle to obtaining a satisfactory functional outcome. Omer's methods[1] for restoration of sensibility described in Green's text include free nerve grafting and free neurovascular cutaneous island flap on a long nerve pedicle, with mention of free vascularized nerve grafts[10] and free neurovascular cutaneous flaps.[11] Reports of return of sensibility after free nerve grafting for ulnar nerve palsy show considerable variation. Millesi and Berger[12] have the largest series of 39 cases, including nine children, with 15% S2+ or less, 56% S3, and 28% S3+ and S4. Haase and associates[13] reported a series of 26 patients with 11% S2+, 15% S3, 46% S3+, and no S4. Review of all reports to date that document end results by sensory testing reveals that 28% have recovered two-point discrimination (S3+ and S4).[14] Digital nerve translocation compares favorably, with 85% of patients obtaining the S3+ or S4 level.

Transfer of a neurovascular cutaneous island flap to restore sensibility was first proposed by Moberg[15] and has been developed technically by Littler[16] and Tubiana and Duparc.[17] It has been described most com-

Table III. Questionnaire to evaluate subjective outcome

Question	*Value*	*Average response*
1. Was the operation helpful in improving the function of your hand?		
Yes 30		
No 0	30	23
2. Do you experience abnormal tingling or coldness in the finger that had sensation restored?		
Often 0		
Weekly 5		
Monthly 7.5		
Never 10	10	6
3. Do you have pain in the finger that had sensation restored?		
Often 0		
Weekly 5		
Monthly 10		
Never 15	15	11
4. Can you sense without looking where your finger is better than before your operation?		
Yes 15		
No 0	15	13
5. Have you injured your hand because of lack of sensation since the operation?		
Yes 0		
No 20	20	14
6. Does the loss of sensation in the finger from which the nerve was taken cause you any problems?		
Yes 0		
No 10	10	7

Average response based on 13 respondents to questionnaire.
Note: Questions 1, 4, 5, and 6 were answered "yes" or "no." The "average response" represents the mean of the scores for the respondents.

monly for restoration of sensibility to the thumb, but the technique has been used in ulnar nerve palsy.[1, 17] Although some authors report return of two-point discrimination[17, 18] with neurovascular island flaps, others have not.[19, 20] Digital nerve translocation reliably provides comparable results with a simpler procedure that avoids the hazards of a neurovascular pedicle skin flap.

Like a neurovascular pedicle flap, digital nerve translocation has the disadvantage of removing sensibility from another portion of the hand. Tubiana and Duparc[17] have discussed the relative values of sensibility in the hand, the most important areas being the thumb, the radial aspect of the index finger, and the ulnar border of the small finger; the least important being the ulnar borders of the ring and long fingers. In the present study, most patients did not believe that the loss of sensibility on the ulnar aspect of the long finger caused significant impairment. Sacrifice of only one of the digital nerves to the finger leaves the proprioception necessary for "blind" function. Three patients reported abnormal sensations in the donor finger that did not cause significant problems. One patient (9) believed that transfer of the nerve left the long finger useless, however, he cited lack of movement because of tendon injuries as the major cause of disability.

After nerve translocation, all patients initially experience sensation as coming from the donor finger. With use and time this improved in most patients. The return of normal sensibility can be greatly enhanced through a sensory reeducation program. After 1981 all patients started sensory reeducation similar to that described by Dellon[21] when gross return of sensibility occurred in the fingertip, usually 3 or 4 months after translocation.

There is significant improvement in sensory recovery with time. The average FSR of patients that were 25 months or less after operation was 63 and those greater than 25 months scored an average of 87. Five patients that had been evaluated in 1983 with an average follow-up of 16 months had an average FSR of 64. When reevaluated with an average follow-up of 80 months, their FSR had improved to 94. These results suggest that sensibility continues to improve more than 2 years after translocation.

Patients' average age was 30 years at the time of digital nerve translocation. Surprisingly, the younger patients did not fare significantly better than the older patients, scoring 85 and 81 points on FSR testing respectively. This may be due to the fact that 2 of the 6 patients who were less than 30 at the time of surgery were the patients that "gave up" using their hand because of extensive injury. Excluding their scores on FSR, the average score for those less than 30 years old was 97.

The time from injury to digital nerve translocation plays an important role in recovery of sensibility. The patients who had the operation within 10 months of injury had an average FSR of 90 while those who were operated on more than 10 months after their injury scored 72. One patient who had the operation 10 years after low ulnar nerve palsy had a FSR score of 95 at follow-up more than 7 years later.

Patients who returned to work fared significantly better than those who did not. The average FSR for the three patients who did not return to work was 61, with an average subjective score of 27. This compares with a FSR of 90 for those who returned to work, and a

Table IV. Patient data and compiled results

Patient	*Age at time of surgery (yr)*	*Time from injury to surgery (mo)*	*Length of follow-up (mo)*	*FSR*	*BMRC*	*Subjective score*	*Type of nerve injury*	*Type of transfer*	*Comments*
1	13	0	301	100	S4	100	Digital	UDNR-> UDNS	Fig. 2
2	23	2	101	92.5	S3+	70	Low median	UDNS-> CDN I&L RDNS-> RDNI UDNR-> UDNT	Fig. 4
3	33	120	96	95	S3+	80	Low ulnar	RDNL-> CDN R&S UDNL-> UDNS	Fig. 5
4	32	9	96	95	S3+	87.5	Low ulnar	UDNL-> UDNS (Standard)	Fig. 1
5	21	10	90	95	S3+	90	Low ulnar	UDNL-> UDNS	Fig. 1
6	29	9	60	50	S2	15	Low ulnar	UDNL-> UDNS	Fig. 1; not working
7	39	54	58	75	S4	95	Low ulnar	UDNL-> UDNS	Fig. 1
8	60	28	5	NA	NA	NA	High ulnar	UDNL-> UDNS	Fig. 1; Died
9	21	240	56	70	S3+	0	Low ulnar	UDNL-> UDNS	Fig. 1; not working
10	19	0	53	NA	NA	77.5	Digital	DUCN-> CDN R&S	Fig. 6; not available for examination
11	24	7	39	100	S4	97.5	Low ulnar	UDNL-> UDNS	Fig. 1
12	50	7	38	100	S4	90	Low ulnar	UDNL-> UDNS	Fig. 1
13	39	15	15	57.5	S3	85	Low ulnar	UDNL-> UDNS	Fig. 1
14	34	19	10	62.5	S3+	65	Low median	UDNR-> RDNI	Fig. 3
15	22	10	6	NA	NA	NA	Low ulnar	UDNL-> UDNS	Fig. 1; short F/U
16	40	8	6	NA	NA	NA	Low ulnar	UDNL-> UDNS	Fig. 1; short F/U
17	33	0	4	NA	NA	NA	High ulnar	UDNL-> UDNS	Fig. 1; short F/U
Average	30 yr	41 mo	78 mo	83	NA	73	Low ulnar	UDNL-> UDNS	
n =	12	12	12	12	12	12		13	

UDNR, Ulnar digital nerve ring finger; UDNS, ulnar digital nerve small finger; CDN I&L, common digital nerve index and long fingers; RDNS, radial digital nerve small finger; RDNI, radial digital nerve index finger; UDNT, ulnar digital nerve thumb; RDNL, radial digital nerve long finger; CDN R&S, common digital nerve ring and small fingers; UDNL, ulnar digital nerve long finger; DUCN, dorsal ulnar cutaneous nerve.

subjective score of 87. The discrepancy in outcome is caused by several factors. Those who did not return to work had more severe injuries than those who did, and they were poorly motivated in their rehabilitation.

This report focuses on the problem of ulnar nerve palsy; however, the technique of digital nerve translocation is useful in many situations with irreparable nerve injury leaving an important portion of the hand anesthetic. The procedure is simple, and long-term follow-up reveals restoration of sensibility that is comparable or better than other available methods with return of two-point discrimination in 85% of patients.

REFERENCES

1. Omer GE. Ulnar nerve palsy. In: Green DP, ed. Operative hand surgery. 2nd ed. New York: Churchill Livingstone, 1988:1535-54.
2. Harris RI. The treatment of irreparable nerve injuries. Can Med Assoc J 1921;11:833-41.
3. Sadr AR. Cross nerve anastomosis in man. Ann Surg 1946;124(3):599-603.
4. Turnbull F. Radial-median anastomosis. J Neurosurg 1948;5:562-6.
5. Hara T, Tsuyama N, Furusawa S. An attempt to regain sensations in the median nerve by transferring the superficial radial nerve to the median nerve. Operation 1973;27:551-8.
6. Chacha PB, Krishnamurti A, Soin K. Experimental sensory reinnervation of the median nerve by nerve transfer in monkeys. J Bone Joint Surg 1977;59A:386-90.
7. Lewis RC, Tenny JR, Irvine D. The restoration of sensibility by nerve translocation. Bull Hosp Jt Dis Orthop Inst 1984;44(2):288-96.
8. Tenny JR, Lewis RC. Digital nerve grafting for traumatic defects: use of the lateral antebrachial cutaneous nerve. J Bone Joint Surg 1984;66A:1375-9.

9. Zachary RB. Results of nerve suture. In: Seddon, HJ, ed. Peripheral nerve injuries. Medical Research Council Report Series No. 282. London: Her Majesty's Stationery Office, 1954:354-88.
10. Taylor GI. Nerve grafting with simultaneous microvascular reconstruction. Clin Orthop 1978;133:56-70.
11. Daniel RK, Terzis J, Midgley RD. Restoration of sensation to an anesthetic hand by a free neurovascular flap from the foot. Plast Reconstr Surg 1976;57(3):275-80.
12. Millesi H, Meissl G, Berger A. Further experience with interfascicular grafting of the median, ulnar and radial nerves. J Bone Joint Surg 1976;58A:209-18.
13. Haase J, Bjerre P, Simesen K. Median and ulnar nerve transections treated with microsurgical interfascicular cable grafting with autogenous sural nerve. J Neurosurg 1980;53:73-84.
14. Mackinnon SE, Dellon AL. Surgery of the peripheral nerve. New York: Thieme Medical Pub, 1988:120-1.
15. Brooks D. The place of nerve grafting in orthopaedic surgery. J Bone Joint Surg 1955;37A:299.
16. Littler JW. Neurovascular pedicle transfer of tissue in reconstructive surgery of the hand. J Bone Joint Surg 1956;38A:917.
17. Tubiana R, Duparc J. Restoration of sensibility in the hand by neurovascular skin island transfer. J Bone Joint Surg 1961;43B:474-80.
18. Markley JM. The preservation of close two-point discrimination in the interdigital transfer of neurovascular island flaps. Plast Reconstr Surg 1977;59(6):812-6.
19. Murray JF, Ord JVR, Gavelin GE. The neurovascular island pedicle flap: an assessment of late results in sixteen cases. J Bone Joint Surg 1967;49A:1285-97.
20. Reid DAC. The neurovascular island flap in thumb reconstruction. Br J Plast Surg 1966;19:234-44.
21. Dellon AL. Evaluation of sensibility and re-education of sensation in the hand. Baltimore: Williams & Wilkins, 1981.