Outcome of ulnar neurolysis during post-traumatic reconstruction of the elbow

Michael D. McKee, Jesse B. Jupiter, Gae Bosse, Laura Goodman

From the University of Toronto, Canada and Harvard University, Boston, USA

We performed ulnar nerve neurolysis and transposition during reconstructive operations on 20 consecutive patients (21 elbows) with neuropathy after the failure of primary treatment of elbow fractures. There were 11 men and nine women with a mean age of 48.3 years. Preoperatively, four elbows were in McGowan stage I, seven in stage II and ten in stage III and the mean Gabel and Amadio ulnar nerve score was 3.2. At a mean follow-up of 32.1 months (24 to 67) we performed comprehensive neurological, functional, electrophysiological and outcome assessments.

Patient satisfaction was high with good pain relief and restoration of hand strength and dexterity. The mean Gabel and Amadio score had improved to 6.5, an improvement of 3.3. There were one excellent, 16 good, 2 fair and 2 poor results; both of the last were due to failure of the underlying elbow reconstruction. Even for advanced stage-II and stage-III lesions we achieved good function, return of intrinsic power, and a high rate of patient satisfaction.

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The cubital tunnel is narrow and the ulnar nerve may be injured in fractures around the elbow¹⁻³ by direct injury, impaction of bony fragments or iatrogenic damage during internal fixation.^{3,4} Subsequent scarring and fibrosis may

cause compression of the nerve, especially if there is prolonged immobilisation or elbow stiffness.⁵⁻⁷

Severe ulnar neuropathy is sometimes the most disabling result of the failure of primary treatment of an injured elbow, but opinion varies considerably in regard to treatment. Ulnar neurolysis and transposition have been described as isolated procedures for cubital tunnel syndrome of various causes,^{5,8-10} but there is little information on the results of neurolysis performed at the time of secondary reconstruction of the elbow. It is widely thought that in advanced lesions with intrinsic muscle wasting the prognosis for recovery of the nerve is poor,^{6,7,9,11} especially in older patients. Previous assessments have concentrated on the effects on the nerve or the joint without full consideration of function in everyday life.¹²⁻¹⁵

We report 20 consecutive patients with post-traumatic ulnar neuropathy who had comprehensive, multidisciplinary assessment after neurolysis and anterior transposition of the ulnar nerve at the time of later reconstruction of injured elbows.

Patients And Methods

Between 1985 and 1992, 60 patients had reconstructive surgery performed by the senior author (JB) for the late effects of injury to the elbow. Of these, 20 (21 elbows) had neurolysis and transposition of the ulnar nerve as part of the procedure; these are the basis of the study. We defined ulnar neuropathy as subjective symptoms in the distribution of the ulnar nerve in the hand and forearm (21 elbows), weakness in the muscles of the hand and forearm innervated by the ulnar nerve (17 elbows) and increased two-point discrimination in the sensory distribution of the nerve in the hand (19 elbows). All patients had at least two of these three features.

We excluded patients who had ulnar neuropathy and elbow pathology which was not secondary to injury, those who did not have objective signs of ulnar neuropathy before their elbow reconstruction and those who had isolated ulnar neuropathy after injury and who then had ulnar neurolysis and transposition alone.

There were 11 men and nine women with a mean age of 48 years (23 to 75). The primary injury of the elbow was an intra-articular fracture of the distal humerus in 14, fracture-

M. D. McKee, MD, FRCS C, Assistant Professor
Upper Extremity Reconstructive Service, Division of Orthopaedics,
Department of Surgery, St Michael's Hospital, University of Toronto,
Toronto, Canada.

J. B. Jupiter, MD, Director
Orthopaedic Hand Service

G. Bosse, MHA, OTR/L, Certified Hand Therapist
Department of Occupational Therapy

L. Goodman, BA, Research Assistant
Orthopaedic Trauma Service
Massachusetts General Hospital, Boston, Massachusetts, USA.

Correspondence should be sent to Dr M. D. McKee at 55 Queen Street East, Suite 800, Toronto, Ontario, Canada M5C 1R6.

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Table I. Details and results in the 20 patients (21 elbows)

Case	Age (yr)	Gender	Original injury	Procedures	Reconstr delay (mth)	McGowan		Gabel & Amadio		Reconstr op indication	Follow-up (mth)	Satisfaction VAS*
						Preop	Postop	Preop	Postop			
1	63	M	Distal hum fract	1	2	I	I	5	7	TEA†	24	6
2	62	F	Distal hum fract	2	18	II	I	2	8	Nonunion	30	9
3	54	F	Distal hum fract	1	6	III	I	1	6	Nonunion	24	9
4	34	F	Olecranon fract	3	14	II	I	4	8	Debridement	67	9
5	55	F	Distal hum fract	1	1	III	I	1	6	Nonunion	24	9
6	35	M	Distal hum fract	2	96	II	I	4	8	Malunion	24	10
7	58	M	Distal hum fract	1	12	III	I	3	7	Malunion	36	10
8	73	M	Distal hum fract	1	12	III	I	4	7	Nonunion	36	10
9	55	F	Distal hum fract	1	12	I	I	5	8	Nonunion	42	6
10	53	F	Distal hum fract	1	6	III	I	2	8	Elbow release	43	10
11	48	F	Distal hum fract	2	6	III	I	4	6	Nonunion	24	8
12	36	M	Fract-disloc elbow	3	12	III	I	3	6	Elbow debridement	24	6
13	23	M	Distal hum fract	2	168	II	I	5	7	Elbow debridement	24	8
14	34	M	Fract-disloc elbow	4	96	III	II	2	2	TEA	24	1‡
15	36	M	Soft-tissue injury, infection	12	18	II	II	2	3	Elbow release	24	5
16 R L	40	M	Fract-disloc elbow	2	6	I	I	4	6	Elbow release	24	10
			Fract-disloc elbow	2	18	II	I	2	6			
17	54	F	Fract-disloc elbow	1	12	II	I	5	7	Nonunion	30	10
18	70	M	Distal hum fract	1	30	III	II	2	6	Nonunion	48	8
19	84	F	Distal hum fract	2	36	III	II	2	6	TEA	24	5‡
20	62	F	Distal hum fract	1	12	I	I	5	9	Nonunion	36	10

* visual analogue scale

† total elbow arthroplasty

‡ did not require further surgery

dislocation of the elbow in five, fracture of the olecranon in one, and a crush injury in one (Table I). The median period from the initial injury to the reconstructive procedure was 12 months (1 to 168) in 19 patients. In one patient (case 13) reconstruction was performed 14 years after the original injury. Post-traumatic disorders included underlying peri-articular malunion or ununited fracture (11), post-traumatic arthritis (7), periarticular heterotopic bone (6) and soft-tissue contracture (5).

Motor function was assessed according to the Medical Research Council (MRC) scale.¹⁶ The muscles tested included the flexor carpi ulnaris, adductor pollicis, abductor digiti quinti, and the first dorsal interosseous muscle. Seven patients had electrophysiological testing before referral and all showed alteration in both sensory conduction velocity and EMG.

We used two clinical staging systems to assess the degree of dysfunction of the ulnar nerve to try to distinguish the results of ulnar neurolysis from the overall elbow reconstruction. The classification of McGowan¹¹ defines a minimal lesion with no detectable motor weakness of the hand as grade I, an intermediate lesion (weakness) as grade II and a severe lesion with paralysis of one or more of the ulnar intrinsic muscles as grade III. The system of Gabel

and Amadio⁵ for evaluation of the outcome of revision surgery scores subjective complaints of pain, objective sensory tests, and motor tests with a point score from 0 to 3 for each. A normal elbow without symptoms scores 9 points.

Operative technique. We used an extensive exposure to reconstruct the intra-articular pathology and to mobilise and perform neurolysis of the ulnar nerve. Because of severe scarring and fibrosis around the elbow the nerve was usually identified proximally beneath the edge of the triceps muscle. In five patients the nerve had been transposed anteriorly at a previous surgical intervention and was found to be encased in periarticular fibrosis, often trapped by bony fragments, heterotopic bone formation, metal implants or suture material. No nerve had been transected.

We performed external neurolysis using either loupe or microscopic magnification with microsurgical techniques and instrumentation. Dissection of the nerve was from proximal to distal, starting 6 to 8 cm above the medial epicondyle. To avoid focal constriction of the nerve, the distal half of the medial intramuscular septum was excised. The nerve was dissected for 5 to 6 cm into the flexor pronator muscle group distal to the medial epicondyle,

taking care to protect and identify the motor branches to the flexor carpi ulnaris. At the conclusion of the operation, the nerve was placed subcutaneously anterior to the medial epicondyle free from any pressure.

All 20 patients (21 elbows) returned for assessment by a multidisciplinary team which included an independent orthopaedic surgeon, a certified occupational hand therapist and a research nurse. The mean follow-up was 32.1 months (24 to 67).

Assessment included a complete history and physical examination and completion of a satisfaction questionnaire and health status surveys (Nottingham Health Profile,¹⁷⁻¹⁹ SF-36^{20,21}). Physical examination included inspection for signs of ulnar neuropathy and two-point discrimination. Grip and pinch strength were measured using Jamar grip and pinch-strength dynamometers. We also performed the Semmes-Weinstein monofilament test,²² the hand function test of Jebsen et al²³ and a nerve-conduction test using a Nervepace digital neurometer.²⁴

Patient satisfaction was recorded on a visual analogue scale to evaluate satisfaction with surgery (0 = completely unsatisfied, 10 = completely satisfied), with similar scales to assess pain, weakness and numbness, with 0 being none, 5 moderate and 10 severe. The predominant preoperative symptom was documented. Patients were specifically asked if they would have the surgery again in similar circumstances. The use of analgesics, symptoms at night, return to employment and any new postoperative symptoms were noted.

Statistical analysis. We assessed statistical correlation between outcomes by the Pearson correlation coefficient and comparison of pre- and postoperative differences in mean values by a paired two-tailed *t*-test. A level of $p < 0.05$ was considered to be statistically significant.

Results

All 21 elbows had at least one previous operation; 11 patients had additional surgery ranging from two to 12 procedures.

Patient satisfaction. Patient satisfaction was high with a mean score of 8.0 (4 to 10). The mean pain score was 3.1 (0 to 8), the mean weakness score 3.5 (0 to 7) and the mean numbness score was 4.1 (0 to 8). Night pain and/or numbness and tingling was completely relieved in 16 patients and reduced to negligible levels in the other four. All patients have been taking narcotic analgesics preoperatively. Postoperatively, 11 patients had no pain attributable to their ulnar nerve, seven had mild pain which did not require any analgesics and two had constant pain that required regular analgesia. Eighteen of the 20 patients said that they would have this surgery again if indicated. Fifteen patients were able to return to their preinjury occupations or level of function, three were forced to change occupations but were still gainfully employed, and two were unable to return to active employment.

Ulnar neuropathy. The mean preoperative Gable and Amadio score was 3.2 points (1 to 5) (Table I); postoperatively, it was 6.5. The mean improvement per patient was 3.3 points (0 to 6). There were one excellent, 16 good, 2 fair and 2 poor results. Both poor results were in patients with failure of the underlying elbow reconstruction. Preoperatively, four limbs were in McGowan grade I, seven in stage II and ten in stage III. Postoperatively, 17 were in stage I (no detectable weakness), four in stage II and none in stage III.

Grip/pinch strength. Examination with the Jamar dynamometer showed grip strengths which averaged 67% of the contralateral side. Lateral pinch strength averaged 71% and tip pinch strength 73% of the unaffected side. The one patient with bilateral elbow problems was not included. Of the 17 patients with intrinsic muscle weakness, paralysis or wasting, 12 recovered grade-5 power, four grade 4, and one remained at grade 3. No patient had a permanent decrease in intrinsic muscle strength as the result of the procedure (Table II).

Semmes-Weinstein monofilament test. All patients except case 16, with bilateral injuries, had normal sensation in the contralateral ulnar nerve as measured by the monofilament test on the volar side of the little finger. Nine patients had normal sensation, eight had diminished light touch, one had diminished protective sensation and three patients had loss of protective sensation. Overall, the mean two-point discrimination was 7 mm. In the four patients with diminished or lost protective sensation it was 13 mm, in the remainder 6 mm ($p = 0.002$). There was a high degree of correlation ($r = 0.7630$, $p = 0.0001$) between the Semmes-Weinstein test and the measured two-point discrimination (Table II).

Jebsen's hand function test. The mean score was 133% (94 to 316) of standardised mean test times. This meant that the average patient required 33% longer to perform a similar manual task with the involved limb than a control group. Two patients, both with failure of the underlying elbow reconstruction, had increased scores of 266% and 316%. The time taken to complete the test had a strong negative correlation with grip ($r = -0.7146$, $p = 0.001$), lateral pinch ($r = -0.6342$, $p = 0.004$) and tip pinch ($r = -0.6179$, $p = 0.005$) strengths. This indicates that increasing grip or pinch strength decreases the time required to perform the test. The time taken to complete the test correlated positively with increased scores in difficulty in completing tasks of daily living of the Nottingham Health Profile ($r = 0.8784$, $p = 0.0001$) (Table II).

SF-36 health survey. The mean 'global' SF-36 score was only 68.2, indicating that these patients had not returned to normal health (Table III). According to the SF-36 score, 19 patients still felt some degree of physical limitation in the involved arm, but only three patients reported a loss of self-image.

Nottingham health profile. The results of part one included a mean reduction in physical mobility of 16%, an increase in pain of 21%, an increase in emotional reaction

Table II. Results of specialist tests

Case	Grip strength	Pinch strength		Semmes-Weinstein	NCV* Nerpace	Jebesen (%)	2-pt (mm)
		Lateral	Tip				
1	58	45	82	3.22	90	120	7
2	57	78	83	3.22	80	113	8
3	62	52	57	3.22	91	115	7
4	97	73	120	2.83	80	104	5
5	50	67	50	3.84	58	139	8
6	100	75	64	2.83	84	103	5
7	102	103	105	2.83	92	121	5
8	70	83	81	3.22	93	94	6
9	50	76	67	2.83	80	149	5
10	107	140	143	3.22	94	107	8
11	61	52	46	3.22	75	120	10
12	48	60	63	3.22	90	107	7
13	85	83	79	2.83	90	134	5
14	12	18	20	3.84	64	266	>15
15	10	20	25	3.84	65	316	10
16 R	-	-	-	2.44		143	6
L	-	-	-	2.44		121	5
17	95	95	90	2.83	80	140	6
18	60	75	70	3.22	70	110	8
19	55	60	55	3.61	62	115	8
20	95	98	90	2.44	70	105	5

* nerve-conduction velocity

Table III. SF-36 scores in 20 patients

Case	Physical function	Physical role	Pain	General health	Vitality	Social function	Emotional role	Mental health
1	50	0	52	45	0	0	0	0
2	85	100	84	92	73	100	100	100
3	85	100	72	100	80	100	100	92
4	100	100	100	95	80	100	100	100
5	55	25	74	92	80	100	100	92
6	85	75	51	77	60	100	67	72
7	65	50	51	42	25	50	100	72
8	90	100	100	75	80	100	100	92
9	80	100	74	72	75	75	100	72
10	85	100	100	77	55	100	100	76
11	87.5	0	74	72	60	100	100	92
12	65	100	31	67	55	25	0	56
13	85	100	80	92	80	100	100	88
14	25	50	22	15	35	25	0	32
15	40	0	22	72	25	50	0	40
16	45	0	52	57	65	75	100	84
17	85	100	80	100	30	37.5	0	64
18	95	100	100	100	100	100	100	100
19	50	75	41	50	35	75	33.3	68
20	50	75	74	72	20	37.5	66.7	64
Mean	70.4	67.5	62.7	73.2	55.9	74.5	68.3	72.8

Table IV. Nottingham Health Profile scores in 20 patients

Physical mobility	16% decrease
Pain	21% increase
Emotional reaction	19% increase
Energy level	21% decrease
Sleep	31% decrease
Social isolation	12.5% increase
Global health	21% decrease

of 19%, a decrease in energy level of 21%, a decrease in sleep of 31%, and an increase in social isolation of 12.5%. Overall, there was a global decrease of 21% (Table IV). Response to part two indicated that five patients had no difficulty with any task, 11 had difficulty with only one or two tasks, and four had difficulty with three or more tasks. Two patients, both with failure of the underlying elbow reconstruction, had difficulty with all seven tasks. On aver-

age, patients reported difficulty performing 31% of the tasks related to their state of health, with inability to perform household chores and hobbies being the most common positive responses.

Electrophysiological testing. Postoperatively, the mean motor nerve-conduction velocity was 31.8 m/s on the affected side and 39.9 m/s on the unaffected side. This represents a mean decrease in nerve-conduction velocity of approximately 20.4% compared with the normal contralateral side (Table II).

Discussion

Ulnar neuropathy is one of the most disabling aspects of the failure of primary treatment of periarticular elbow injuries,¹⁻⁴ but there is little information about treatment and outcome. Patients with advanced neuropathy including wasting of intrinsic muscles or paralysis are thought to have a poor outcome.^{6,7,9-11} Most reports include such patients in larger series which have had ulnar nerve neurolysis and transposition done in isolation for cubital tunnel syndrome for a variety of causes.^{5,8-10} Our series represents a unique group of patients who required ulnar neurolysis at the time of extensive post-traumatic elbow reconstruction. This aspect has not been previously reported.

Previous studies by Geutjens et al²⁵ and Tsujino et al²⁶ have shown the patients with ulnar neuropathy, either of spontaneous onset or associated with osteoarthritis of the elbow, can be treated surgically by simple decompression and release of the nerve rather than transposition. As with our technique a common feature is the complete release of the nerve from any constricting or enveloping fascia, fibrosis or bony impingement. One of the advantages of the limited procedure which they describe is the decreased amount of soft-tissue dissection. In our patients, this dissection had usually been done before as part of the reconstruction of the elbow. Thus, transposition of the nerve added little to the procedure. In many of our patients the presence of metal implants made anterior transposition of the nerve preferable.

Our findings suggest that good functional results, return of intrinsic muscle power and a high rate of patient satisfaction can be achieved after ulnar neurolysis at the time of elbow reconstruction, even in stage-II and stage-III lesions with intrinsic muscle weakness or paralysis. We always performed complete release of the nerve and transfer to a tension-free position. In addition, the successful reconstruction of the elbow allowed early postoperative movement; this helps to prevent the scarring and fibrosis around the nerve seen after previous procedures with prolonged immobilisation in a cast. This is confirmed by the poor neurological outcome associated with the failure of the elbow reconstruction in two of our cases. Early movement has been shown to be beneficial to the repair of periarticular nerve injuries.²⁷

Most of our patients had successful objective and sub-

jective outcomes. Patient satisfaction was high and the use of analgesics was decreased or eliminated in most, as was night pain or paraesthesiae. Improvement in muscle strength correlated with favourable completion times on Jebsen's hand function test. Nerve-conduction velocity postoperatively was similar to that after the release of other entrapment neuropathies.^{9,24,28} Our mean improvement in outcome score of 3.3 points per patient according to the system of Gabel and Amadio⁵ correlated well with the mean score for nerve function and with the 2.9 points improvement per patient seen in their series of 30 patients who had revision for failed decompression.

Our patients had general improvement, but did not feel that they had a 'normal' limb. Measurement of functional outcome by the SF-36 health status survey and the Nottingham health profile is more sensitive for revealing residual disability or functional deficits than the traditional or objective measures usually used to assess outcome.¹⁷⁻²¹ In our series, 95% of the patients still felt some degree of physical limitation in the involved upper limb. We consider that assessment of all such patients would be enhanced by the inclusion of special measures of functional outcome. Most of our patients were able to return to active employment, but significant impairment in the performance of health-related activities was noted by the NHP survey.

Our study has three potential weaknesses. The first is the difficulty in differentiating between the nerve and underlying joint problem. Since the two are interrelated, such a distinction may be artificial, but we have used some criteria that are more specific for nerve and hand function in our assessment. Secondly, there is a lack of preoperative data on EMG or nerve-conduction velocity in our patients, but the clear clinical diagnosis of ulnar neuropathy in most of our cases made these tests unnecessary. Thirdly, our study would have been enhanced by the addition of preoperative data on general health status, which would have allowed a more accurate assessment of the effect of our procedure on the patient's overall health.

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