Autogenous Vein Wrapping versus In Situ Decompression for Management of Secondary Cubital Tunnel Syndrome after Surgical Fixation of Elbow Fractures: Short-Term Functional and Neurophysiological Outcome

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Abstract

Purpose The aim of this study was to compare the functional and neurophysiological outcome of in situ decompression versus in situ decompression augmented with autogenous vein wrapping in management of secondary cubital tunnel syndrome at the elbow following fixation of elbow fractures.

Methods A prospective comparative randomized study was performed on 29 patients who were divided into two groups: group I (in situ decompression) and group II (in situ decompression augmented with autogenous vein wrapping). We measured the patients' demographics, subjective reports of symptoms, and objective evaluation of the functional and neurophysiological outcomes of both groups.

Results Group II patients achieved statistically better results in both neurophysiological scoring and clinical sensory rating but not in all other parameters.

Conclusion Autogenous vein wrapping for secondary cubital tunnel syndrome after elbow fracture fixation only provides a better sensory outcome.

Level of Evidence Level II, therapeutic prospective comparative study.

Keywords

- ▶ vein wrapping
- ▶ in situ decompression
- ▶ secondary cubital tunnel syndrome
- ▶ elbow fractures

Introduction

Cubital tunnel syndrome (CuTS) is the second most common entrapment neuropathy in the upper extremity after carpal tunnel syndrome.^{1,2} Ulnar nerve entrapment following open reduction and internal fixation (ORIF) of elbow fractures could be categorized as secondary CuTS.^{3,4}

Management of secondary CuTS comprises both nonoperative and operative treatments. Operative treatment is indicated for cases resistant to nonoperative treatment for more than 6 weeks, chronic cases, and for cases exhibiting neurological deficits.¹ Available surgical options include in situ decompression (whether traditional or endoscopic), decompression with partial medial epicondylectomy, decompression and anterior

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transposition procedures (subcutaneous, intramuscular, and submuscular), and more recently decompression and vein wrapping procedures.^{1,5,6}

The aim of this study was to compare the functional and electrophysiological outcome of two surgical procedures—in situ decompression and in situ decompression augmented with autogenous vein wrapping—in the management of secondary CuTS following operative fixation of elbow fractures.

Methods

A prospective comparative randomized study was conducted on 29 patients who were diagnosed as having secondary CuTS following operative fixation of fractures around the elbow based on clinical and electrodiagnostic findings. The study ran from June 2008 to December 2013.

Inclusion criteria: The following are the inclusion criteria: (1) history of previous fractures around the elbow that were managed operatively with ORIF through either medial or posterior approaches necessitating routine exploration of the ulnar nerve as a basic step of the procedure with subsequent development of secondary CuTS; (2) failure of conservative treatment for at least 6 weeks; (3) age of the patient older than 12 years to negate bias of better anticipated outcome of pediatric population; and (4) a preoperative active range of motion (ROM) of the elbow of at least 90 degrees, which we owe to two reasons—a limited ROM of the elbow is not alleged as an etiology for the secondary CuTS and obviating one of the indications for anterior ulnar nerve transposition.

Exclusion criteria: The exclusion criteria of this study are as follows: (1) primary CuTS; (2) other causes of secondary CuTS (e.g., cubitus valgus deformity, diabetes mellitus, systemic arthritis, and space-occupying lesions such as ganglia); (3) known ulnar nerve injured at the primary injury or operation; (4) patients who were managed percutaneously; and (5) active elbow ROM of <90 degrees.

Preoperative evaluation: All patients involved in this study were assessed clinically and radiologically. Neither scans nor ultrasonography was done. Neurophysiological evaluation was performed by a single examiner who has practiced neurophysiology for more than 12 years. The neurophysiological evaluation was performed on four occasions for each patient: 1 week preoperatively and then postoperatively after 3, 6, and 12 months. The ulnar neuropathy was graded with *Gabel and Amadio scoring system*.⁷ Points were given based on

the severity of three factors: motor function, sensory function, and level of pain (► **Table 1**). No points were given for the most severe symptoms, while an increasing number of points were given for less severe symptoms. The postoperative outcomes were graded into excellent, good, fair, and poor according to the same scoring system (► **Table 2**). Neurophysiological assessment was graded according to the *Padua classification system* into five categories⁸:

1. *No ulnar neuropathy: normal*
2. *Mild ulnar neuropathy: slowing of ulnar motor nerve conduction velocity (MNCV) across the elbow and a normal ulnar sensory nerve action potential (SNAP)*
3. *Moderate ulnar neuropathy: slowing of ulnar MNCV and ulnar SNAP*
4. *Severe ulnar neuropathy: absent ulnar SNAP and slowing of MNCV*
5. *Extreme ulnar neuropathy: absent motor and sensory responses*

Patients were divided via simple random selection. Preoperatively, each patient was asked to pick a number from a container containing 60 pieces of paper with the numbers from 1 to 60. According to the number selected (even or odd) they were allocated to one of two groups: (1) group I—in situ decompression of the ulnar nerve and (2) group II—in situ decompression of the ulnar nerve augmented with autogenous vein wrapping.

Group I comprised 15 patients (8 males and 7 females) with a mean age of 41 years (SD: 12.8; range: 22–60 years). We treated eight left and seven right elbows. Thirteen patients had distal humeral fractures, and two had medial epicondyle fractures. The mean of the time between the ORIF and ulnar nerve decompression was 10.1 months (SD: 3.7; range: 6–18 months). The mean follow-up period was 17.6 months (SD: 3.5; range: 12–24 months) (► **Table 3**).

Group II included 14 patients (9 males and 5 females) with a mean age of 44.2 years (SD: 17; range: 20–75 years). We treated seven right and seven left elbows. Thirteen patients sustained distal humeral fractures and only one patient had a medial epicondyle fracture. The mean of the time between the initial surgery and ulnar nerve decompression and vein wrapping was 9.1 months (SD: 3.3; range: 3–18 months). The mean follow-up period was 24.3 months (SD: 6.4; range: 18–36) months (► **Table 3**). The preoperative clinical rating and neurophysiological grading of both groups are demonstrated in ► **Tables 3 and 4**.

Table 1 Gabel and Amadio rating scale for ulnar nerve entrapment⁷

Score (points)	Motor	Sensory	Pain
3	Normal	No numbness	No pain
2	Weaker than opposite side	Two-point discrimination normal; intermittent paraesthesia	Intermittent pain
1	Obvious atrophy	Two-point discrimination > 6 mm; constant numbness	Constant pain, intermittent medications
0	Intrinsic paralysis with claw deformity	Two-point discrimination > 10 mm; anesthesia	Needs narcotics regularly

Table 2 Classification of outcome based on Gabel and Amadio scores⁷

Excellent	Score of 9
Good	Score of 2 or more points in each category with an increase in score in each category of 1 or more points, or an increase in total score of 4 or more points
Fair	Score less than 2 points in any category, but with an increase in total score of 1 to 3 points
Poor	No change or decline in total score

Operative Details

Under general or regional anesthesia, the patient lay in lateral decubitus position with shoulder abducted to 90 degrees and elbow flexed to 90 degrees. Tourniquet was applied at the midarm above systolic blood pressure of 100 mm Hg.

Surgical Technique

In Situ Decompression

The skin incision design and length were planned according to the incision of the previous procedure of elbow fixation. Thus, if the original approach of fixation was posterior, the planned incision was posterior including the previous scar that was excised followed by developing a medial skin flap to expose the ulnar nerve, which was always entrapped within a

Table 3 Preoperative and demographic data of patients of both groups

Parameter	Group I	Group II
Age (y), mean $\pm$ SD	41 $\pm$ 12.8	44.2 $\pm$ 17
Sex, N		
Male	8	9
Female	7	5
Side, N		
RT	7	7
LT	8	7
Initial trauma, N		
Distal humeral fracture	13	13
Medial epicondyle fracture	2	1
Time from initial surgery to definitive surgery (mo), mean $\pm$ SD	10.1 $\pm$ 3.7	9.1 $\pm$ 3.3
Preoperative Gabel and Amadio rating scale		
Motor, mean $\pm$ SD	0.5 $\pm$ 0.7	0.3 $\pm$ 0.5
Sensory, mean $\pm$ SD	1 $\pm$ 0.8	0.9 $\pm$ 0.9
Pain, mean $\pm$ SD ($p = 0.02$)	1.3 $\pm$ 0.7	0.8 $\pm$ 0.4
Total, mean $\pm$ SD	2.9 $\pm$ 1.7	1.9 $\pm$ 1
Preoperative EDS, mean $\pm$ SD	4 $\pm$ 0.8	4.1 $\pm$ 0.9

Abbreviations: EDS, electro diagnostic studies; LT, left; RT, right.

Table 4 Gabel and Amadio preoperative rating scale for ulnar nerve entrapment of group I and II patients

	Grade	Number	
		Group I	Group II
Motor	III		
	II	2	
	I	4	4
	0	9	10
Sensory	III		
	II	5	4
	I	5	4
	0	5	6
Pain ($p = 0.13^a$)	III		
	II	7	
	I	6	11
	0	2	3

^aStatistically significant results.

heavy scar tissue in all cases in a nearly typical manner. Alternatively, if the original approach was medial, the planned incision was medial including the previous scar. In both situations, the new incision was extended 2 cm proximally and 2 cm distally. The extension of the incision aimed at facilitating the dissection and release of the ulnar nerve by starting at a healthy nonscarred zone. Osborne ligament was identified and released. The fascia over the ulnar nerve was divided, and meticulous microscopic external $\pm$ internal neurolysis was performed, freeing the nerve all around for 360 degrees. In this study, the authors did not need to perform internal neurolysis at any case. The whole scarred ulnar nerve segment, plus 2 cm both proximally and distally, was released. The nerve release was completed up to the medial intermuscular septum (MIS) proximally to release the band between the triceps and the brachialis and up to the deep flexor-pronator aponeurosis distally. The arcade of Struthers and the MIS were divided. Distally, the confluence of the two heads of the flexor carpi ulnaris was gently separated, to avoid muscular weakness postoperatively. A redivac was routinely applied followed by release of the tourniquet. The surgical wound was routinely closed with interrupted sutures. A soft antiseptic dressing was applied to the site of surgical incision, and the elbow was maintained at posterior above elbow removable orthosis in the flexed position for the next 2 weeks so that the patient obtain maximal allowable stretch of the ulnar nerve in the postoperative period while performing gradually progressing rehabilitation program. This protocol aimed at maximum reduction of pain and adhesions.

Vein Wrapping Procedure

The contralateral lower extremity was used for harvesting the great saphenous vein so that two teams could operate together. A small 1-cm transverse incision was made anterior

to the medial malleolus, where the great saphenous vein was identified, and a vein stripper was used to harvest the vein with the required length, which was approximately three to four times the length of the scarred nerve. The required length of the vein was determined according to the condition of the underlying bed and the diameter of the nerve. The remaining vein was ligated both proximally and distally. With the help of skin hooks, the graft was held straight and incised longitudinally, using a pair of sharp scissors. The split vein was then wrapped in a helical configuration around the whole length of neurolyzed nerve. The vein-to-vein junctures were sutured carefully with 6-0 nylon sutures. The vein was routinely tagged to the underlying bed both proximally and distally by 6-0 nylon suture. This aims at minimizing the tension at the vein-vein junctures, thus maximizing the stability of the vein graft construct. A redivac was routinely applied followed by release of the tourniquet. After routine closure and dressing, elbow was maintained at posterior above elbow removable orthosis in the flexed position for the next 2 weeks.⁹

Postoperative Care for Both Groups

Both groups were managed similarly. The skin sutures were removed after 2 weeks. From day 1 postoperatively, all patients started a graduated program of passive and active elbow motion thrice daily to enhance nerve gliding. After 14 days, the orthosis was discarded and an intensive rehabilitation program under supervision of an expert upper limb physical therapist was initiated till the end of the sixth week.

Technique of Neurophysiological Examination

Neurophysiological examination was performed in all patients using Nihon Kohden MEB-9400K Neuropack S1 [Nihon Kohden Corporation, Nishiochai, Tokyo, Japan] equipment. Motor and sensory distal latencies, amplitudes of compound

muscle action potential, MNCV, and sensory nerve conduction velocity were measured using standard methodologies.¹⁰ Abductor digiti minimi was used as primary recording site, with the first dorsal interosseous being the alternative recording site.¹¹ The ulnar nerve was stimulated above wrist, below and above elbow, and in the axilla. The little finger was used for the SNAP recording.

Statistical Analysis of the Data

Independent sample t-test was used for quantitative data, while the *chi-square test* was used for qualitative data. *The Mann-Whitney test* was used for nonparametric quantitative data. *Paired sample t-test* was used to compare the preoperative and postoperative findings in both groups. The *p*-value of < 0.05 was used to indicate significance.

This study was approved by the human ethical committee council of our center.

Results

On clinical grading at final review, there were 1 excellent, 4 good, 10 fair, and no poor results in group I (► **Table 5**). In group II, there were one excellent, nine good, four fair, and no poor results (*p* = 0.107). The only statistically significant clinical change was the improvement in sensibility, which was significantly better in group II (*p* = 0.021) (► **Table 5**).

Neurophysiologically, three patients achieved grade II, eight patients grade III, and four patients grade IV in group I. In group II, one patient achieved grade I, eight patients grade II, three patients grade III, and two patients grade IV (*p* = 0.036). This indicates superiority of neurophysiological response in group II patients, as the lower the grade of neurophysiological response, the better the improvement, as demonstrated by Padua et al.⁸

There was a significant clinical (pain, motor power, and sensory domain) and neurophysiological improvement from

Table 5 Postoperative data of patients of both groups

Parameter	<i>p</i> -Value	Group I	Group II
Length of vein graft (cm)			25.3 ± 1.9
Follow-up period (mo), mean ± SD	0.003 ^a	17.6 ± 3.5	24.3 ± 6.4
Postoperative Gabel and Amadio rating scale			
Motor, mean ± SD	0.23	1.2 ± 0.9	1.6 ± 0.9
Sensory, mean ± SD	0.02 ^a	2.1 ± 0.6	2.6 ± 0.5
Pain, mean ± SD	0.396	2.5 ± 0.6	2.7 ± 0.5
Total, mean ± SD	0.11	5.8 ± 1.9	6.9 ± 1.6
Postoperative EDS, mean ± SD	0.036 ^a	3.1 ± 0.7	2.4 ± 0.9
Grading, <i>N</i>			
Excellent		1	1
Good		4	9
Fair		10	4

Abbreviations: EDS, electro diagnostic studies.

^aStatistically significant results.

Table 6 The relation between the age and the lag of interference to the clinical and neurophysiological outcome using Pearson correlation

	Examined parameter	Age		Lag of interference	
		<i>r</i>	<i>p</i> -Value	<i>r</i>	<i>p</i> -Value
Group I	Motor	−0.842	<0.001 ^a *	−0.176	0.547
	Sensory	−0.626	0.017 ^a	0.084	0.776
	Pain	−0.505	0.065 ^a	0.324	0.258
	Total	−0.863	<0.001 ^a	0.019	0.948
	EDS	0.815	<0.001 ^a	0.113	0.702
Group II	Motor	−0.095	0.736	−0.668	0.006 ^a
	Sensory	−0.333	0.255	−0.397	0.143
	Pain	−0.076	0.788	−0.245	0.380
	Total	−0.181	0.519	−0.549	0.034 ^a
	EDS	0.276	0.32	0.493	0.062 ^a

Abbreviations: EDS, electro diagnostic studies.

^aStatistically significant results.

the preoperative status to the postoperative status in both groups ($p < 0.001$).

Using Pearson correlation, in group I patients the age was negatively correlated to the final clinical scoring value and grading. Neurophysiologically, the age demonstrated statistically significant positive correlation ($r = 0.491$; $p = 0.045$). Similarly, in group II patients the age demonstrated statistically significant negative correlation to all examined clinical parameters (motor power, $p < 0.001$; sensory domain, $p = 0.017$; pain, $p = 0.065$;

total mean score, $p < 0.001$), while neurophysiologically there was statistically significant positive correlation ($r = 0.844$; $p < 0.001$) (► **Table 6**).

In group I patients, there was negative correlation between lag of interference and all examined clinical parameters with significant correlation to both motor power and total mean score ($p = 0.006$ and 0.034 , respectively). Neurophysiologically, the lag of interference demonstrated statistically significant positive correlation ($r = 0.493$; $p = 0.062$). On the other

Table 7 The relation between the age and the lag of interference to the outcome of the postoperative score applying the Kruskal–Wallis and the Mann–Whitney tests

	Fair (I)	Good (II)	Excellent (III)	p-Value		
Group I						
	N = 10	N = 4	N = 1			
Age (y), range (mean ± SD)	22–60, (43.6 ± 14.4)	28–42, (34 ± 5.9)	48 (48)	0.395		
				I vs. II	I vs. III	II vs. III
				0.257	0.874	0.157
Lag of interference, range (mean ± SD)	6–18, (11.5 ± 3.6)	6–11 (7.8 ± 2.4)	6 (6)	0.083 ^a		
				I vs. II	I vs. III	II vs. III
				0.063 ^a	0.151	0.429
Group II						
	N = 4	N = 9	N = 1			
Age (y), range (mean ± SD)	60–75 (66 ± 6.4)	20–50 (36.7 ± 10.1)	25 (25)	0.014 ^a		
				I vs. II	I vs. III	II vs. III
				0.005 ^a	0.157	0.295
Lag of interference, range (mean ± SD)	8–18 (11 ± 4.7)	5–13 (8.4 ± 2.7)	8 (8)	0.396		
				I vs. II	I vs. III	II vs. III
				0.213	0.264	0.86

^aStatistically significant results.

hand, in group II patients, there was positive correlation to all examined clinical and neurophysiological parameters with the exception of the motor power. The positive correlation of both age and lag of interference to the neurophysiological results could be explained by the fact that the lower the score of neurophysiology the better is the improvement.

The relation between the age and the lag of interference to the outcome of the postoperative score applying the Kruskal–Wallis and the Mann–Whitney tests is depicted in **Table 7**.

In group I patients, females achieved better postoperative clinical and neurophysiological scoring with significant superiority in pain and total scoring ($p = 0.064$ and 0.073 , respectively). In group II patients, females achieved better postoperative clinical and neurophysiological scoring with significant superiority in only pain ($p = 0.035$). The operated side has no significant impact on the measured parameters in group I patients. In group II, right-side affected patients achieved better results with significant improvement in motor power rating, total scoring, and neurophysiological response ($p = 0.02$, 0.034 , and 0.055 , respectively).

The average length of the harvested saphenous vein graft was 25.3 cm (SD: 1.9; range: 22–28 cm).

Discussion

Numerous surgical techniques have been advocated for management of secondary CuTS that failed nonoperative treatment. However, no consensus exists in the literature regarding the optimal surgical treatment for such problem. That is why, numerous comparative studies have been made to investigate the most appropriate technique for surgical treatment of secondary CuTS and technical selection according to preoperative classification and clinical findings.¹²

Secondary CuTS occurs in 50% of cases of distal humeral fractures, which could be attributed to anatomical proximity of the nerve to the zone of injury, intraoperative manipulation, or postoperative cicatrix formation.¹³ In this study, we put special emphasis on secondary CuTS after previous surgical intervention involving standard nerve exploration. Previous reports suggest that cicatrix formation is the most common cause of persistent or recurrent ulnar nerve compression in the upper extremity, which may be owed to impairing epineurial blood flow, producing nerve compression or traction, and impairing nerve gliding. On the same track, the same pathology is expected to be the chief cause for secondary CuTS following fixation of elbow fractures.^{12,13}

When the main underlying cause of the secondary CuTS is heavy scarring, the objective of surgical intervention will be relieving compression, which is basically achieved either via formal open in situ decompression of the ulnar nerve with or without external/internal neurolysis throughout the entire cubital tunnel together with preserving neural vascularity or via more conservative endoscopic technique that would avoid more scarring.^{13–17} However, in the authors' view, the formal open in situ decompression will be more suitable for the cases of both groups involved in this study due to the heavy tough scarring encountered in all cases that could not be amenable to release via

endoscopic technique. Currently, the goals are expanded to include relieving compression neuropathy of the ulnar nerve and preventing postoperative adhesions, thus minimizing recurrence rate which puts the foundation for orthobiologic nerve insulators.

Hand surgeons have introduced the use of orthobiologic insulator alternatives which may be nonresorbable, natural resorbable, or synthetic resorbable. The ideal nerve insulator will be biocompatible, mechanically stable while being biodegradable, flexible, semipermeable, and accommodating the nerve swelling without producing any compression.^{18,19}

Autogenous vein wrapping for scarred nerves represents an ideal example for nerve insulators which has been used effectively for the treatment of peripheral neuropathy in both experimental and clinical settings.^{5,6,9,20} The main advantages provided through this technique were the following: forming a barrier around the operated nerve, thereby preventing both compression and adhesions via decreasing fibroblast infiltration; enhancing nerve function and regeneration through vein graft–derived neurotropic factors; improving nerve gliding; and providing a path for the regenerating axons in cases of partially or completely injured nerves.²⁰

In an interesting study evaluating the fate of ulnar nerve following ORIF of distal humeral fractures, ulnar nerve injury was evaluated to take place in 10.1% of cases.¹³ In the same study, the authors concluded that prophylactic ulnar nerve anterior transposition was not protective. On the other hand, ulnar neuropathy complicating olecranon fractures has been reported to be between 2 and 10% for direct traumatic, intraoperative, and subsequent compressive injury.²¹

In our study, the application of the combined in situ decompression and autogenous vein wrapping resulted in statistically better results in sensibility with better nonsignificant results in all other examined parameters.

In group I patients, the age was negatively correlated to the final clinical scoring value and grading. Similarly, in group II patients, the age demonstrated statistically significant negative correlation to all examined clinical parameters. In both groups, the age and lag of interference showed positive correlation to the neurophysiological response value which negatively reflected the degree of improvement.

A retrospective analysis over a 20-year period was performed which included 480 patients who underwent neurolysis (179) and anterior subcutaneous transposition (301).¹⁷ They found that the only statistically significant advantage of neurolysis over transposition was the relief of localized elbow pain. On our study, all examined clinical parameters were better in group II patients, with the statistically significant results achieved in the sensory domain.

Despite the efficiency of in situ decompression, inadequate release of the nerve and the potential for recurrent subluxation may formulate a defect of the procedure.²²

We conclude that the autogenous vein wrapping procedure for ulnar nerve entrapment after elbow fracture fixation is comparable to isolated in situ decompression, achieving significantly better results for those patients suffering mainly from sensory deficits, with better overall results from both clinical and neurophysiological point of view.

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