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A Population-Based Study of Ulnar Neuropathy at the Elbow in Washington State Workers' Compensation

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Background *There are no population-based studies of return to work after ulnar neuropathy at the elbow (UNE). We examine the predictors of return to work following a diagnosis of work-related UNE.*

Methods *Workers diagnosed with work-related UNE between 1995 and 2000 were identified from the administrative records of the Washington State workers' compensation system (n = 2,863). The medical records of 250 randomly selected surgical cases were reviewed. The end of wage replacement, our primary outcome, is a surrogate marker of the potential ability to return to work. Cox proportional hazards regression analyses were used to model duration of wage replacement as a function of select sociodemographic, clinical, electrodiagnostic, and disability predictors.*

Results *The mean wage replacement and medical benefits paid per case were $19,100 and $15,200, respectively. Older age, concomitant carpal tunnel syndrome, receipt of wage replacement benefits prior to diagnosis, and longer diagnostic delays were associated with lower return to work potential after injury. Type of treatment (surgical or conservative care) was not associated with return to work. Among surgically treated workers, receipt of wage replacement before establishing a diagnosis was inversely associated with return to work in multivariate models that included clinical severity and electrodiagnostic criteria.*

Conclusion *Work-related UNE is a common and costly occupational health challenge. Efforts to accurately diagnose UNE and maximize functional recovery should start in the first medical encounter. Older workers, those who have concomitant carpal tunnel syndrome, or who are already receiving wage replacement benefits at the time of diagnosis deserve special attention.* Am. J. Ind. Med. 53:1242–1251, 2010. *© 2010 Wiley-Liss, Inc.*

KEY WORDS: cubital tunnel syndrome; ulnar neuropathy at the elbow; workers' compensation; population-based; return to work

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INTRODUCTION

Ulnar neuropathy at the elbow (UNE), or cubital tunnel syndrome, as it is commonly termed, is the second most common entrapment neuropathy in the upper extremity after carpal tunnel syndrome [McPherson and Meals, 1992]. It is typically caused by nerve traction with prolonged elbow flexion (e.g., cell phone users and musicians) or by direct trauma to the ulnar nerve along its superficial path in the elbow as with excessive leaning on the elbows among office workers and drivers [Apfelberg and Larson, 1973; Werner et al., 1985; Charness et al., 1996; Darowish et al., 2009].

The diagnosis is often made on the basis of history and physical examination [Darowish et al., 2009]. The utility of electrodiagnostic studies are in confirming, locating, and gauging the severity of the ulnar nerve injury as well as determining the pathophysiology of the lesion (e.g., demyelination vs. axon loss) [Kincaid, 1988; Piligian et al., 2000].

Conservative treatment measures such as activity modifications, ergonomic adjustments, and anti-inflammatory medications may be effective in mild cases. Surgical decompression and/or transposition of the ulnar nerve are warranted when conservative measures fail and in moderate or severe cases [Seradge and Owen, 1998; Dellon, 2000]. However, the best surgical treatment remains debated [Brauer and Graham, 2007; Chung, 2008] and it is potentially influenced by surgeons' preferences [Dellon, 1989].

Population-based studies assessing work-related outcomes of non-traumatic UNE are lacking [van Tulder et al., 2007]. In the present population-based retrospective cohort study we will describe Washington state workers diagnosed with UNE between 1995 and 2000. Our specific objectives were to address the following questions: (1) What sociodemographic, clinical, and disability variables (such as baseline wage, presence of concomitant carpal tunnel syndrome, and receipt of wage replacement) are associated with return to work? (2) Are there differences in return to work between those treated surgically and those treated conservatively? and (3) Does meeting the case definition of work-related UNE predict post-surgical outcomes?

METHODS

Washington State Workers' Compensation System

Washington state law requires all non-federal employers to provide workers' compensation insurance through a state fund unless they qualify to be self-insured. Approximately two-thirds of the state's non-federal workforce is insured through the Department of Labor and Industries state fund.

The Department of Labor and Industries workers' compensation system maintains an extensive administrative claims, medical bill payment, and wage replacement databases. The claims database includes the type of injury, date of injury, industry, occupation, and demographic information. The medical bill database includes diagnoses, procedures, dates of service, and providers. The wage replacement database provides information on all benefits paid for temporary total disability (work disability). These benefits are paid when a worker has missed more than 3 days from work and are stopped when a worker is determined to be medically stable and able to work.

Data Acquisition and Patient Selection

After obtaining the appropriate ethical approval from the University of Washington, all Washington state workers who had the International Classification of Diseases-Ninth revision (ICD-9) code 354.2 as their primary diagnostic code between January 1, 1995 and December 31, 2000 were identified from the medical bill payments databases of the Department of Labor and Industries. Self-insured workers were not included in the analysis due to unavailable or incomplete data.

We identified 3,597 potential cases, 734 of which were excluded. Workers were excluded if their claim was filed prior to 1993 ($n = 232$), their injury was related to direct trauma or fracture ($n = 231$) or involved distant body parts ($n = 271$). Among the 2,863 workers with non-traumatic UNE, the Current Procedural Terminology (CPT) code 64718 was used to identify workers who underwent decompression and/or transposition of the ulnar nerve in the elbow ($n = 749$; Fig. 1).

Of the 749 surgically treated workers, 250 were randomly selected for medical record review to ascertain the following information: (1) the motor and sensory signs and symptoms of UNE, (2) the results of provocative testing such as Tinel's sign and the elbow flexion test, and (3) the results of the Nerve Conduction Velocity (NCV) and electromyography (EMG) tests.

For the purposes of the present study, work-related UNE is defined as cases that have satisfied all of the following three case definition criteria:

(1) evidence of work-relatedness, which is assumed in all cases since all claims used in this study were accepted by Washington State workers' compensation system, and
(2) sensory and/or motor findings by history and physical examination consistent with UNE, that is,
    (a) one or more of the following symptoms suggestive of UNE: numbness, tingling, paresthesia affecting at least part of the ulnar nerve distribution of the hand, and/or
    (b) objective findings present in the affected arm: either positive Tinel's sign at the elbow or elbow

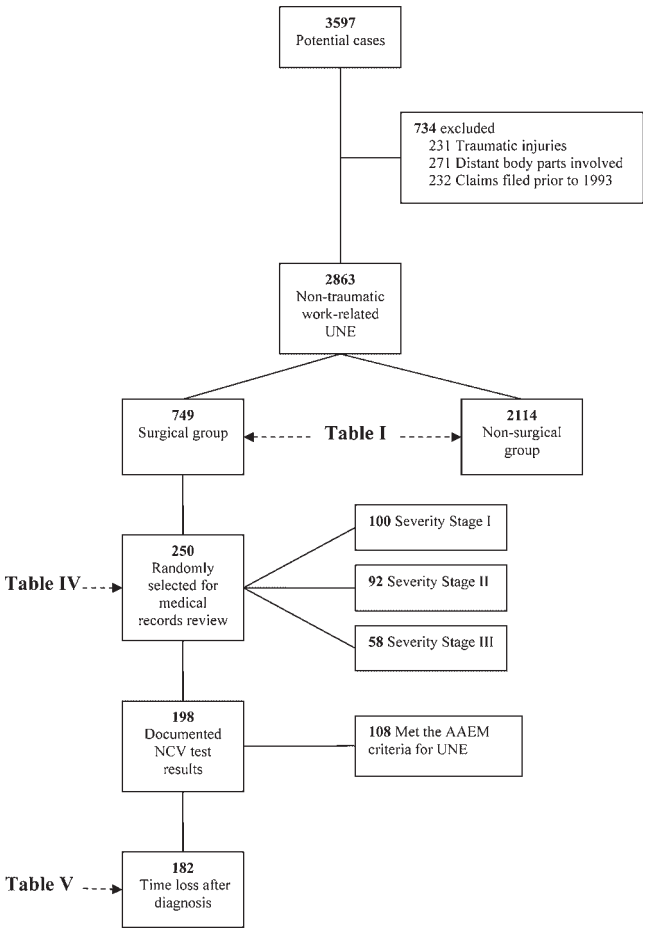

FIGURE 1. Study population: workers diagnosed with work-related non-traumatic UNE. Washington State workers' compensation system (1995–2000). UNE, ulnar neuropathy at the elbow; NCV, nerve conduction velocity test; AAEM, American Association of Electrodiagnostic Medicine.

flexion test, or abnormal 2-point discrimination, diminished or absent sensation to pinprick or pressure, and muscle weakness in the ulnar nerve distribution of the hand; and

(3) meeting at least two of the four American Association of Electrodiagnostic Medicine (AAEM) criteria for UNE as recommended by the AAEM guidelines [American Association of Electrodiagnostic Medicine, 1999; Campbell, 1999; Thibault et al., 2005]:

   (i) above elbow (AE)-to-below elbow (BE) NCV of <50 m/s.
   (ii) AE-to-BE NCV of >10 m/s slower than the BE-to-wrist NCV.
   (iii) compound motor action potential (CMAP) decrease of $>20\%$ between AE and BE waveforms.
   (iv) CMAP configuration change between AE and BE waveforms.

Cases were classified into three stages of clinical severity based on Dellon's criteria [1989]. Stage I (mild) includes workers with intermittent sensory symptoms, no muscular weakness, with or without positive provocative tests. Stage II (moderate) includes workers with intermittent sensory symptoms, muscular weakness, and positive provocative tests. Stage III (severe) includes workers with persistent sensory symptoms, abnormal 2-point discrimination, muscle weakness, positive elbow flexion test, and/or positive Tinel's sign.

Data Analysis

Workers certified by their physicians to be totally and temporarily disabled from work for more than 3 days due to a work-related injury or illness are entitled to receive wage replacement benefits for temporary total disability from the Department of Labor and Industries (time loss payments). Therefore, receipt of wage replacement benefits indicates temporary total disability and is used as a proxy estimate of the duration of functional disability. The end of wage replacement, our primary outcome, signals functional recovery and the potential ability to return to work.

Survival analysis techniques were used to model wage replacement duration as a function of age, gender, marital status, baseline wage, concomitant carpal tunnel syndrome, time from initiating the worker's compensation claim to establishing the diagnosis, receipt of wage replacement prior to diagnosis, and treatment modality (surgical vs. non-surgical). Cox regression models were used in these analyses. The proportional hazards assumption was satisfied for each categorical variable. Analyses were stratified based on the treatment modality, surgical versus non-surgical. Statistical significance was set at two-tailed $P \leq 0.05$. For the relative hazard ratio, the 95% confidence intervals were reported. Data analyses were performed using the statistical software packages of SAS (SAS Institute, Inc., Cary, NC) and SPSS (SPSS, Inc., Chicago, IL).

RESULTS

A total of 2,863 Washington state workers were diagnosed with work-related UNE between January 1, 1995 and December 31, 2000. Of them, 749 underwent surgical decompression or transposition of the ulnar nerve (26.1%) and 2,114 were treated conservatively (73.8%). The surgical group differed from the non-surgical group in terms of mean age at injury (40 years old vs. 39 years old), percent male (62% vs. 56%), and percent with concomitant carpal tunnel syndrome (59% vs. 45%). Of all workers, 57% were married, 12% earned less than $1,000 per month, and 2% earned more than $5,000 per month (Table I).

Work disability was more prevalent among surgically treated workers than among workers treated conservatively

TABLE I. Characteristics of Workers Diagnosed With Non-Traumatic Work-Related Ulnar Neuropathy at the Elbow by Treatment Modality: Washington State Workers' Compensation System (1995–2000)

	Treatment modality		
Characteristic	**Surgical (n = 749)**	**Non-surgical (n = 2,114)**	**Total (n = 2,863)**
Sociodemographic			
Age at injury, mean (range), year*	40 (18–76)	39 (17–82)	39 (17–82)
Gender (% male)*	62	56	57
Marital status (% married)	57	57	57
Baseline monthly wage (%)			
<$1,000	11	13	12
$1,000–$2,000	38	37	37
$2,001–$3,000	28	29	29
$3,001–$4,000	15	15	15
$4,001–$5,000	6	4	5
>$5,000	2	2	2
Clinical			
Concomitant carpal tunnel syndrome (%)*	59	45	48
Disability			
Any wage replacement (temporary total disability) (%)*	93	61	69
Wage replacement prior to diagnosis (%)*	57	45	48
Wage replacement after diagnosis (%)*	89	48	59
Wage replacement duration (%)*			
<1 month	8	14	12
1–3 months	22	20	21
4–5 months	14	15	14
6–12 months	18	15	16
>1 year	38	35	36
Cost[a]			
Wage replacement benefits, mean (range)*	21.7 (0.0–229.7)	17.6 (0.0–196.4)	19.1 (0.0–229.7)
Medical benefits, mean (range)*	16.8 (1.3–156.3)	14.3 (0.0–167.4)	15.2 (0.0–167.4)

[a]Cost in thousands of dollars.
*A statistically significant difference between the surgical and non-surgical groups ($P \leq 0.05$).

(93% vs. 61%) and tended to last longer as 56% of surgically treated workers received wage replacement benefits for more than 6 months compared to 50% of the conservatively treated group. The mean medical and disability costs of work-related UNE were higher for the surgical cases than for the non-surgical cases.

Of the 2,863 workers with work-related UNE, 1,697 received wage replacement benefits after their diagnosis; their characteristics are summarized in Table II. There were no significant differences in terms of gender, marital status, or baseline wages between the surgical and non-surgical groups of workers who received wage replacement after being diagnosed with work-related UNE. However, the surgical group tended to have concomitant carpal tunnel syndrome more often than the non-surgical group (61% vs. 55%) and to be slightly older at the time of injury as 18% of surgically treated workers were 50 years of age or older at the time of injury compared to 15% of those treated conservatively.

The results of the univariate and multivariate analysis of the possibility of ending wage replacement and returning to work are presented in Table III. Return to work was less likely among workers injured at an older age. For instance, workers who were 50 years of age or older at the time of injury were 35% less likely to return to work at any point of time compared to workers who were less than 30 years old (HR, 0.65; 95% CI, 0.52–0.77).

Workers with a concomitant carpal tunnel syndrome were 11% less likely to return to work at any time than workers without carpal tunnel syndrome (HR, 0.89; 95% CI, 0.80–0.99). The time frame between initiating a workers' compensation claim and establishing a diagnosis of UNE was significant in predicting return to work. Workers who received their diagnosis within a month of initiating their

TABLE II. Baseline Characteristics of Workers Who Received Wage Replacement After Being Diagnosed With Work-Related Ulnar Neuropathy at the Elbow, per Treatment Modality: Washington State Workers' Compensation System (1995–2000)

	Treatment modality		
Characteristic	**Surgical (n = 672)**	**Non-surgical (n = 1,025)**	**Total (n = 1,697)**
Sociodemographic			
Age at injury (%) year*			
≤29	12	16	14
30–39	39	38	38
40–49	31	31	31
≥50	18	15	16
Gender (% male)	61	59	60
Marital status (% married)	57	57	57
Baseline monthly wage (%)			
<$1,000	11	11	11
$1,000–$2,000	38	39	39
$2,001–$3,000	28	29	29
$3,001–$4,000	16	16	16
$4,001–$5,000	6	4	5
>$5,000	2	2	2
Clinical			
Carpal tunnel syndrome (%)*	61	55	58
Time from initiating workers' compensation claim to establishing UNE diagnosis (%)*			
≤1 month	32	30	31
>1 month	68	70	70
Disability			
Received wage replacement prior to diagnosis (%)*	61	72	68

*A statistically significant difference between the surgical and non-surgical groups ($P \leq 0.05$).

workers' compensation claim were 13% more likely to return to work than workers whose diagnosis was delayed for over a month (HR, 0.87; 95% CI, 0.77–0.99). Workers who received some wage replacement benefits prior to establishing the UNE diagnosis were 43% less likely to return to work at any point than workers who had not (HR, 0.57; 95% CI, 0.50–0.65). Although surgically treated workers seemed to be less likely to return to work than those conservatively treated, this association did not reach statistical significance (HR, 0.90; 95% CI, 0.81–1.01).

The medical records of 250 randomly selected surgical cases were reviewed and the results are summarized in Table IV. The clinical severity of UNE was categorized into three stages based on the above-mentioned Dellon's criteria. There were 100 mild cases (40%), 92 moderate cases (37%), and 58 severe UNE cases (23%).

Of the 250 randomly selected surgical cases, 198 had documentation of NCV test results, 47 were tested but the numerical results were missing, and 5 were never tested. These results were categorized as diagnostic of UNE if they met at least two of the four AAEM criteria. All the 198 surgical cases with NCV documentation were accepted workers' compensation claims and had a history and physical examination compatible with UNE (100%). However, only 108 cases met the AAEM criteria for UNE; therefore, only 54.5% of the 198 surgical cases met the case definition for work-related UNE (Fig. 1).

Needle EMG was performed in 112 cases (57%) and showed evidence of denervation in the ulnar nerve distribution in 36 cases (18%). Electrodiagnostic evidence supportive of carpal tunnel syndrome was present in 92 cases (46%) and of cervical radiculopathy in 5 cases (3%).

Table V provides the results from the univariate and multivariate Cox regression analysis for return to work among the 182 of 198 surgical workers with NCV results, who received wage replacement benefits after their diagnosis. Having concomitant carpal tunnel syndrome, receipt of wage replacement prior to establishing a diagnosis, and longer duration between initiating a worker's compensation claim and establishing a diagnosis predicted lower chances for return to work in the univariate analysis. However, in the multivariate analysis, only receipt of wage replacement

TABLE III. Return to Work Among Workers Who Received Wage Replacement After Being Diagnosed With Work-Related Ulnar Neuropathy at the Elbow (N = 1,697), Cox Proportional Hazards Regression Models: Washington State Workers' Compensation System (1995–2000)

	Relative hazard for return to work (95% CI)	
Variable	**Univariate analysis**	**Multivariate analysis[a]**
Sociodemographic		
Age at injury (years)		
≤29 (reference)	1	1
30–39	**0.75 (0.64–0.88)**	**0.74 (0.63–0.87)**
40–49	**0.70 (0.59–0.82)**	**0.71 (0.60–0.84)**
≥50	**0.65 (0.54–0.79)**	**0.65 (0.52–0.77)**
Gender		
Female (reference)	1	1
Male	**0.88 (0.79–0.98)**	0.92 (0.82–1.03)
Marital status		
Not married (reference)	1	1
Married	0.98 (0.88–1.09)	0.99 (0.88–1.10)
Baseline monthly wage		
<$1,000 (reference)	1	1
$1,000–$2,000	1.05 (0.88–1.26)	1.04 (0.87–1.25)
$2,001–$3,000	0.99 (0.82–1.20)	0.98 (0.81–1.19)
$3,001–$4,000	0.91 (0.74–1.12)	0.94 (0.76–1.17)
$4,001–$5,000	0.82 (0.60–1.11)	0.82 (0.60–1.12)
>$5,000	0.86 (0.54–1.35)	0.89 (0.56–1.43)
Clinical		
Concomitant carpal tunnel syndrome		
No (reference)	1	1
Yes	**0.90 (0.80–0.99)**	**0.89 (0.80–0.99)**
Surgery		
No (reference)	1	1
Yes	0.93 (0.83–1.04)	0.90 (0.81–1.01)
Disability		
Time from initiating workers' compensation claim to establishing UNE diagnosis		
≤1 month (reference)	1	1
>1 month	**0.67 (0.60–0.75)**	**0.87 (0.77–0.99)**
Wage replacement prior to diagnosis		
No (reference)	1	1
Yes	**0.54 (0.49–0.61)**	**0.57 (0.50–0.65)**

CI, confidence interval; UNE, ulnar neuropathy at the elbow.
Bold values indicate statistically significant findings ($P < 0.05$).
[a]Multivariate analysis adjusted for the sociodemographic, clinical, and disability variables.

benefits prior to diagnosis was inversely associated with return to work. Workers who were already receiving wage replacement benefits at the time of their diagnosis were 40% less likely to return to work at any point in time compared with workers who were not. Neither the sociodemographic, nor the clinical or electrodiagnostic factors predicted return to work after surgery in the multivariate analysis.

DISCUSSION

In this large population-based cohort of injured workers, we examined the significant predictors of return to work after UNE. Greater age at injury, the presence of concomitant carpal tunnel syndrome, longer time to establish a diagnosis, and initiating wage replacement prior to establishing a diagnosis significantly predicted lower chances of return to

TABLE IV. Summary of the Work-Related UNE Diagnostic Criteria as Documented in the Medical Records of the Randomly Selected Surgical Cases (n = 250): Washington State Workers' Compensation System (1995–2000)

Diagnostic criteria	N (%)
History	
Numbness/tingling/paresthesia in the 4th and 5th digits	241 (96)
Elbow pain	211 (84)
Physical examination	
Positive Tinel's sign	199 (79)
Positive elbow flexion test	62 (25)
Abnormal 2-point discrimination	55 (22)
Decreased sensation in the 4th and 5th digits	113 (45)
Hand weakness in the ulnar distribution muscles	60 (24)
Clinical severity [Dellon, 1989]	
Mild (Stage I)	100 (40)
Moderate (Stage II)	92 (37)
Severe (Stage III)	58 (23)

UNE, ulnar neuropathy at the elbow.

work. The choice of treatment was not a significant predictor of return to work. For workers who underwent surgical decompression or transposition of the ulnar nerve, receipt of wage replacement prior to establishing a diagnosis was the single significant predictor of failure to return to work independent of the sociodemographic, clinical, and electrodiagnostic factors.

There were over 2,800 workers' compensation claims for non-traumatic UNE in Washington State workers' compensation system between 1995 and 2000. Approximately one in four underwent surgical decompression or transposition of the ulnar nerve (26%). Based on Dellon's clinical severity criteria [1989], 40% of surgically treated UNE cases were mild, 37% were moderate, and 23% were severe.

Disability was common in this population regardless of the treatment as 52% received wage replacement benefits for over 6 months and nearly half the workers were already receiving benefits before the diagnosis was established (48%). A primary purpose of the study was to identify the significant predictors of favorable return to work outcome, which is an important step in minimizing work disability.

The presence of concomitant carpal tunnel syndrome was associated with lower return to work potential. Nearly half the workers had a diagnosis of carpal tunnel syndrome (48%) and its presence was associated with an 11% lower likelihood for return to work at any time. Our results agree with those of Seradge and Owen [1998] who reported worse surgical outcomes among workers who had carpal tunnel syndrome. The concomitant presence of two cumulative trauma disorders may be the result of exposure to highly repetitive work to which workers are unable or unwilling to resume. Additionally, the lower return to work potential may be due to the additional time needed for the treatment and recovery for two syndromes or due to imprecision of diagnosis, with inappropriate treatment of one of the entrapment neuropathies. The latter possibility is suggested by the fact that a significant proportion (45.4%) of the surgical cases did not meet the AAEM criteria for UNE and therefore did not meet our case definition for work-related UNE. Although positive electrodiagnostic testing is typically required prior to surgery [Urbaniak and Gabel, 1991], it has not been a consistent requirement [Dellon and Mackinnon, 1988; McPherson and Meals, 1992]. More recently, new guidelines on the surgical management of UNE implemented in Washington State [Washington State Department of Labor and Industries, 2010] require both classic clinical symptoms and signs and positive electrodiagnostic testing before approval of surgery for UNE.

Ending time loss is strongly associated with improved pain and function, and with return to work. However, time loss may also end if a worker is found to be employable and stable medically. Thus, use of ending time loss, while standard in outcomes research in workers' compensation, has some limitations which may limit interpretation of results [Fulton-Kehoe et al., 2007]. Consistent with previous evidence among compensated workers [Maghout Juratli et al., 2006], older workers were less likely to return to work after work-related UNE injury than younger workers. This inverse association between age and return to work was independent of the clinical and electrodiagnostic severity, which argues against the possibility that the lower potential for return to work among older workers was related to more severe injuries. However, recovery may be slower in older workers and they may have more comorbidities that interfered with the successful return to work.

Workers who received wage replacement benefits before diagnosis were significantly less likely to return to work than workers who were not. Of all workers with work-related UNE, receipt of wage replacement before establishing a diagnosis was associated with a 43% lower likelihood of return to work at anytime. Similarly, among surgically treated workers, receipt of wage replacement prior to diagnosis was inversely associated with return to work and was associated with a 40% lower likelihood of return to work after surgery. This association was significant even after controlling for the sociodemographic, clinical, and electrodiagnostic factors. It is possible that early work restriction is a marker of injury severity due to acute trauma; however, this is unlikely in the present study because we excluded claims with traumatic injuries. Further, although we do not have a measure of self-rated pain intensity, which has been previously linked to receipt of wage replacement benefits [Turner et al., 2000, 2004, 2007], the inverse association between early wage replacement and return to work after surgery remained significant in the multivariate models accounting for Dellon's clinical severity criteria and the

TABLE V. Return to Work Among Surgically Treated Workers for Work-Related UNE, Who Received Wage Replacement After Diagnosis and Had Documented NCV results (N = 182), Cox Proportional Hazards Regression Models: Washington State Workers' Compensation System (1995–2000)

	Relative hazard for return to work (95% CI)	
Variable	**Univariate analysis**	**Multivariate analysis[a]**
Sociodemographic		
Age at injury (years)		
≤29 (reference)	1	1
30–39	0.75 (0.43–1.32)	0.74 (0.40–1.38)
40–49	1.11 (0.63–1.94)	0.96 (0.52–1.78)
≥50	0.81 (0.44–1.50)	0.68 (0.35–1.34)
Gender		
Female (reference)	1	1
Male	0.87 (0.63–1.20)	0.79 (0.56–1.13)
Marital status		
Not married (reference)	1	1
Married	1.21 (0.87–1.67)	1.16 (0.81–1.67)
Baseline monthly wage		
<$1,000 (reference)	1	1
$1,000–$2,000	0.92 (0.52–1.60)	0.97 (0.54–1.73)
$2,001–$3,000	0.94 (0.53–1.68)	0.87 (0.47–1.61)
$3,001–$4,000	0.80 (0.42–1.50)	0.81 (0.41–1.60)
$4,001–$5,000	0.57 (0.22–1.47)	0.64 (0.24–1.73)
>$5,000	0.72 (0.21–2.46)	0.92 (0.26–3.25)
Clinical		
Met the AAEM criteria		
No (reference)	1	1
Yes	0.95 (0.69–1.32)	0.86 (0.60–1.23)
Concomitant carpal tunnel syndrome		
No (reference)	1	1
Yes	**0.64 (0.46–0.89)**	0.69 (0.48–1.01)
Clinical stages of severity		
Mild (reference)	1	1
Moderate	1.05 (0.72–1.53)	1.12 (0.75–1.68)
Severe	1.28 (0.83–1.98)	1.07 (0.65–1.74)
Disability		
Time from initiating workers' compensation claim to establishing UNE diagnosis		
≤1 month (reference)	1	1
>1 month	**0.56 (0.40–0.78)**	0.73 (0.48–1.11)
Wage replacement prior to diagnosis		
No (reference)	1	1
Yes	**0.49 (0.35–0.68)**	**0.60 (0.39–0.90)**

UNE, ulnar nerve neuropathy at the elbow; NCV, nerve conduction velocity test; AAEM, American Association of Electrodiagnostic Medicine.

Bold values indicate statistically significant findings ($P < 0.05$).

[a]Multivariate analysis adjusted for the sociodemographic, clinical, and disability variables.

AAEM electrodiagnostic criteria. Therefore, it is possible that removing workers from work is influenced by providers' preferences. Providers with low threshold for removing workers from work before establishing a diagnosis are probably more likely to extend work removal for long durations. The new WA state guideline on the treatment of UNE recommends not removing workers from work due to UNE unless surgery is contemplated [Washington State

Department of Labor and Industries, 2010]. Furthermore, the self-perpetuating nature of work disability is consistent with other studies of compensated workers showing that return to work may be independent of clinical diagnosis and biological severity [Franklin et al., 1994; Maghout Juratli et al., 2006]. There are many factors intrinsic and extrinsic to the worker such as psychosocial factors or the work environment that may contribute to the duration of work disability [Turner et al., 2007, 2008], but which are often missing from medical records and were not independently assessed in the present study.

A delay of over 1 month before establishing a diagnosis was predictive of lower return to work potential. Workers diagnosed over a month from initiating their workers' compensation claim were 13% less likely to return to work than those who were diagnosed sooner. The diagnostic delay may have forestalled effective treatments and allowed for irreversible neural axonal changes [Urbaniak and Gabel, 1991]. However, a similar adverse effect on outcome of carpal tunnel surgery has also been reported [Daniell et al., 2005]; thus, timeliness of diagnosis is likely critical for successful outcome of work-related UNE.

Consistent with the literature, the electrodiagnostic results did not predict post-surgical outcomes [Seradge and Owen, 1998; Novak et al., 2002]. The interpretation of this finding should take into consideration the variable sensitivity [Britz et al., 1996; Landau et al., 2003] of these tests especially in the early stages of UNE when symptoms tend to be intermittent. This finding should not undermine the value of electrodiagnostic testing in confirming the diagnosis of UNE even though it may not reliably rule it out.

The mean medical and wage replacement costs of work-related non-traumatic UNE averaged almost $35,000: $15,200 in medical costs and $19,100 in wage replacement costs. Although the surgical cases cost on average $4,000 more in wage replacement expenses and $2,000 more in medical expenses than the non-surgical cases, both were costly. These costs are undoubtedly an underestimate of the total costs that include diminished work performance because of the injury (presenteeism), the cost of alternate work assignments, and training replacement workers.

The limitations of the study are the retrospective design, and the fact that this is not a randomized controlled trial. Despite the wealth of information in the administrative and medical records, these records are not exhaustive and important information such as the working environment, educational attainment, tobacco smoking, body mass index, and medical and psychiatric comorbidities were not routinely reported. Furthermore, we were unable to differentiate between the different surgical approaches reflected in the single billing code used to identify the surgical cases. This has limited our ability to compare the outcomes of decompression with the different transposition approaches of the ulnar nerve. However, studies have shown them to have comparable clinical outcomes and therefore we do not expect the return to work outcome to be significantly different [Bartels et al., 2005; Gervasio et al., 2005; Nabhan et al., 2005; Zlowodzki et al., 2007]. Lastly, job title categories were not available to us in the present study, which could have helped identify highly repetitive jobs contributing to the co-occurrence of cubital tunnel and carpal tunnel syndromes.

Although the cases occurred between 1995 and 2000, there has not been a major change in the diagnosis or treatment of UNE. The newer surgical approaches such as endoscopic techniques have not been compared in a randomized controlled fashion to the traditional approaches to determine if they are superior [Lubahn, 2009], and the endoscopic techniques are not recommended in current WA state guidelines [Washington State Department of Labor and Industries, 2010]. Additionally, the fact that this study is exclusive to compensated workers is a strength; however, it may limit the generalizability of the results to workers in a non-compensation setting. Studies have found that compensated workers have worse outcomes than non-compensated workers for nearly every procedure that has been investigated [Harris et al., 2005].

This study has other strengths. To our knowledge, this is the first and largest population-based study of injured workers that examines work-related outcomes of UNE. It is representative of the practice in the entire state of Washington because it is not restricted to a single surgeon's practice or a particular healthcare system. The study case definition for work-related UNE should prove useful clinically and in future research concerned with UNE. Furthermore, the combined review of medical and administrative records allowed us to evaluate work-related outcomes while adjusting for the electrodiagnostic and clinical severity ratings.

In conclusion, in this study we describe the largest population to date of compensated workers with work-related UNE. UNE is a common and costly occupational health challenge that deserves more attention to minimize the individual and societal cost of disability. Older age at injury, concurrent carpal tunnel syndrome, longer delays before establishing a diagnosis, and being out of work when the diagnosis was made strongly predicted lower possibility of return to work after work-related UNE regardless of the treatment modality. Among surgically treated workers, being out of work before establishing a diagnosis was the single significant predictor of failure to return to work independent of the sociodemographic, clinical, and electrodiagnostic factors. Therefore, efforts to minimize work disability should start as early as the first medical encounter.

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REFERENCES

American Association of Electrodiagnostic Medicine, American Academy of Neurology, American Academy of Physical Medicine and Rehabilitation. 1999. Practice parameter for electrodiagnostic studies in ulnar neuropathy at the elbow: Summary statement muscle nerve, p S171–S205.

Apfelberg DB, Larson SJ. 1973. Dynamic anatomy of the ulnar nerve at the elbow. Plast Reconstr Surg 51:79–81.

Bartels RH, Verhagen WI, van der Wilt GJ, Meulstee J, van Rossum LG, Grotenhuis JA. 2005. Prospective randomized controlled study comparing simple decompression versus anterior subcutaneous transposition for idiopathic neuropathy of the ulnar nerve at the elbow: Part 1. Neurosurgery 56:522–530.

Brauer CA, Graham B. 2007. The surgical treatment of cubital tunnel syndrome: A decision analysis. J Hand Surg Eur 32:654–662.

Britz GW, Haynor DR, Kuntz C, Goodkin R, Gitter A, Maravilla K, Kliot M. 1996. Ulnar nerve entrapment at the elbow: Correlation of magnetic resonance imaging, clinical, electrodiagnostic, and intraoperative findings. Neurosurgery 38:458–465, discussion 465.

Campbell WW. 1999. Guidelines in electrodiagnostic medicine. Practice parameter for electrodiagnostic studies in ulnar neuropathy at the elbow. Muscle Nerve Suppl 8:S171–S205.

Charness ME, Ross MH, Shefner JM. 1996. Ulnar neuropathy and dystonic flexion of the fourth and fifth digits: Clinical correlation in musicians. Muscle Nerve 19:431–437.

Chung KC. 2008. Treatment of ulnar nerve compression at the elbow. J Hand Surg Am 33:1625–1627.

Daniell WE, Fulton-Kehoe D, Chiou LA, Franklin GM. 2005. Work-related carpal tunnel syndrome in Washington State workers' compensation: Temporal trends, clinical practices, and disability. Am J Ind Med 48:259–269.

Darowish M, Lawton JN, Evans PJ. 2009. Q: What is cell phone elbow, and what should we tell our patients? Cleve Clin J Med 76:306–308.

Dellon AL. 1989. Review of treatment results for ulnar nerve entrapment at the elbow. J Hand Surg Am 14:688–700.

Dellon AL. 2000. Diagnosis and treatment of ulnar nerve compression at the elbow. Tech Hand Up Extrem Surg 4:127–136.

Dellon AL, Mackinnon SE. 1988. Human ulnar neuropathy at the elbow: Clinical, electrical, and morphometric correlations. J Reconstr Microsurg 4:179–184.

Franklin GM, Haug J, Heyer NJ, McKeefrey SP, Picciano JF. 1994. Outcome of lumbar fusion in Washington State workers' compensation. Spine (Phila, PA) 19:1897–1903, discussion 1904.

Fulton-Kehoe D, Gluck J, Wu R, Mootz R, Wickizer TM, Franklin GM. 2007. Measuring work disability: What can administrative data tell us about patient outcomes? J Occup Environ Med 49:651–658.

Gervasio O, Gambardella G, Zaccone C, Branca D. 2005. Simple decompression versus anterior submuscular transposition of the ulnar nerve in severe cubital tunnel syndrome: A prospective randomized study. Neurosurgery 56:108–117, discussion 117.

Harris I, Mulford J, Solomon M, van Gelder JM, Young J. 2005. Association between compensation status and outcome after surgery: A meta-analysis. J Am Med Assoc 293:1644–1652.

Kincaid JC. 1988. AAEE minimonograph #31: The electrodiagnosis of ulnar neuropathy at the elbow. Muscle Nerve 11:1005–1015.

Landau ME, Barner KC, Campbell WW. 2003. Optimal screening distance for ulnar neuropathy at the elbow. Muscle Nerve 27:570–574.

Lubahn JD. 2009. Treatment of ulnar nerve compression at the elbow. J Hand Surg Am 34:782, author reply 782–783.

Maghout Juratli S, Franklin GM, Mirza SK, Wickizer TM, Fulton-Kehoe D. 2006. Lumbar fusion outcomes in Washington State workers' compensation. Spine 31:2715–2723.

McPherson SA, Meals RA. 1992. Cubital tunnel syndrome. Orthop Clin North Am 23:111–123.

Nabhan A, Ahlhelm F, Kelm J, Reith W, Schwerdtfeger K, Steudel WI. 2005. Simple decompression or subcutaneous anterior transposition of the ulnar nerve for cubital tunnel syndrome. J Hand Surg Br 30:521–524.

Novak CB, Mackinnon SE, Stuebe AM. 2002. Patient self-reported outcome after ulnar nerve transposition. Ann Plast Surg 48:274–280.

Piligian G, Herbert R, Hearns M, Dropkin J, Landsbergis P, Cherniack M. 2000. Evaluation and management of chronic work-related musculoskeletal disorders of the distal upper extremity. Am J Ind Med 37:75–93.

Seradge H, Owen W. 1998. Cubital tunnel release with medial epicondylectomy factors influencing the outcome. J Hand Surg Am 23:483–491.

Thibault MW, Robinson LR, Franklin G, Fulton-Kehoe D. 2005. Use of the AAEM guidelines in electrodiagnosis of ulnar neuropathy at the elbow. Am J Phys Med Rehabil 84:267–273.

Turner JA, Franklin G, Turk DC. 2000. Predictors of chronic disability in injured workers: A systematic literature synthesis. Am J Ind Med 38: 707–722.

Turner JA, Franklin G, Heagerty PJ, Wu R, Egan K, Fulton-Kehoe D, Gluck JV, Wickizer TM. 2004. The association between pain and disability. Pain 112:307–314.

Turner JA, Franklin G, Fulton-Kehoe D, Sheppard L, Wickizer TM, Wu R, Gluck JV, Egan K, Stover B. 2007. Early predictors of chronic work disability associated with carpal tunnel syndrome: A longitudinal workers' compensation cohort study. Am J Ind Med 50:489–500.

Turner JA, Franklin G, Fulton-Kehoe D, Sheppard L, Stover B, Wu R, Gluck JV, Wickizer TM. 2008. ISSLS prize winner: Early predictors of chronic work disability: A prospective, population-based study of workers with back injuries. Spine (Phila, PA) 33:2809–2818.

Urbaniak JR, Gabel GT. 1991. Perspectives on the operative treatment of cubital tunnel syndrome. Operative nerve repair and reconstruction. Philadelphia: Lippincott. p 1121–1130.

van Tulder M, Malmivaara A, Koes B. 2007. Repetitive strain injury. Lancet 369:1815–1822.

Washington State Department of Labor Industries. 2010. Medical treatment guidelines: Work-related ulnar neuropathy at the elbow (UNE) diagnosis and treatment.

Werner CO, Ohlin P, Elmqvist D. 1985. Pressures recorded in ulnar neuropathy. Acta Orthop Scand 56:404–406.

Zlowodzki M, Chan S, Bhandari M, Kalliainen L, Schubert W. 2007. Anterior transposition compared with simple decompression for treatment of cubital tunnel syndrome. A meta-analysis of randomized, controlled trials. J Bone Joint Surg Am 89:2591–2598.