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Long term symptomatic, functional, and work outcomes of carpal tunnel syndrome among construction workers

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Abstract

Background—The long-term outcomes of carpal tunnel syndrome (CTS) including symptoms, functional status, work disability, and economic impact are unknown.

Methods—We conducted a retrospective study of 234 active construction workers with medical claims for CTS and 249 workers without CTS claims; non-cases were matched on age, trade, and insurance eligibility. We conducted telephone interviews with cases and non-cases and collected administrative data on work hours.

Results—Compared to non-cases, CTS cases were more likely to report recurrent hand symptoms, decreased work productivity/quality, decreased performance of physical work demands, and greater functional limitations. Surgical cases showed larger improvements on multiple outcomes than non-surgical cases. Minimal differences in paid work hours were seen between cases and non-cases in the years preceding and following CTS claims.

Conclusions—Persistent symptoms and functional impairments were present several years after CTS diagnosis. Long-term functional limitations shown by this and other studies indicate the need for improved prevention and treatment.

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Institution at which the work was performed: Washington University School of Medicine in St. Louis

CONFLICT OF INTEREST

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CONTRIBUTORS

All coauthors participated in this study. Drs. Evanoff, Franzblau, Dale and Ms. Strickland planned and conducted the research; all authors were involved in interpretation of the data analysis. Dr. Gardner was the primary writer, with all authors contributing to and editing portions of the manuscript. All authors reviewed the final manuscript. All authors are accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

ETHICS REVIEW AND APPROVAL

The Washington University Institutional Review Board approved this study. All study participants signed informed written consent.

Keywords

disability; musculoskeletal disorders; administrative data; impairment; economic impact

INTRODUCTION

Carpal tunnel syndrome (CTS) is associated with prolonged work disability and functional limitations (Daniell, et al., 2005, Daniell, et al., 2009, Turner, et al., 2007)(U.S. Bureau of Labor Statisitics, 2013). A recent study of the long-term loss in earnings borne by workers with CTS showed that on average CTS claimants only recovered to about half of their pre-injury earnings level relative to comparison groups after 6 years and had periods of time loss up to three times longer than general workers with upper extremity fractures (Foley, et al., 2007). Predictors of lower earnings among CTS claimants were older age, unstable pre-claim employment, and work in construction; workers who had surgery generally had better outcomes than those who did not have surgery (Foley, et al., 2007).

Despite the economic and disability impacts of CTS, few studies have evaluated long-term natural history of CTS, either for symptom and functional status, or for work and disability outcomes. Few studies were truly population-based studies of all cases of CTS (DeStefano, et al., 1997, Wellman, et al., 2004), as distinct from surgical cases or workers' compensation cases. Only 2 studies (Katz, et al., 1998, Padua, et al., 2001) were prospective, though the duration of follow-up was modest relative to the duration of exposure to potentially significant covariates. Most studies have involved only administrative or medical chart data, with no direct data collection from the subjects, thus limiting their ability to include many self-reported and objectively measured predictors in analyses. Even with these limitations, a number of themes emerge. Work disability is common in people who have been diagnosed or treated for CTS (Amick, et al., 2004, Daniell, et al., 2005, Daniell, et al., 2009, Gimeno, et al., 2005, Turner, et al., 2007). Predictors of prolonged disability include baseline functional status, involvement with the workers' compensation system, higher physical demands at work, higher psychological demand at work, and low social or organizational support at work (Amick, et al., 2004, Gimeno, et al., 2005).

Construction is a particularly high risk industry for CTS and other upper extremity musculoskeletal disorders (MSD)(Armstrong, et al., 2008, Forde, et al., 2005, Franklin, et al., 1991, Rosecrance, et al., 2002). Despite the high rates of CTS in the construction industry, studies of work and functional impacts of CTS in construction workers are very limited. Among persons with CTS studied in the Massachusetts Sentinel Event Notification System for Occupational Risk (SENSOR) project, construction workers had the highest rates of prolonged work loss among all workers, were the least likely to receive any intervention, the least likely to have changes to equipment or work environment, and the least likely to receive training on the causes of CTS (Wellman, et al., 2004).

Studies of the long-term functional outcomes and natural course of CTS are thus limited, as are studies of work and functional impacts of CTS in construction workers despite their increased risk. The objective of this study was to describe retrospectively the natural course of CTS among construction workers including outcomes of symptoms, functional status,

work disability, and economic impact. We hypothesized that workers diagnosed with CTS would have greater functional impairment, more time loss from work, and greater likelihood of leaving their job or trade than workers without CTS. Among workers with CTS, we expected that functional impairments would be seen for many years following the onset of CTS, and that greater disability would be seen in older workers, and those with co-morbid medical conditions. We also expected that workers with CTS who received surgery would have greater functional impairments and disability, and greater loss in work hours for a prolonged period of time compared to the non-surgical cases.

METHODS

Recruitment of cases and non-cases

Participants for this study were identified through two programs that manage the employee benefits (pension, health and disability) and health insurance claims for all active members from the carpenters' and floorlayers' unions in St. Louis, MO. Eligibility for benefits was based on active union membership and the number of hours worked in a given calendar period. Representatives from the benefits fund identified all potential cases as members with claims for treatment of CTS (ICD-9 354.0) from 2003 through 2010. Case and non-case volunteers were invited to participate using the same script; they were asked to participate in a study on carpal tunnel syndrome to better understand the impact of the disease on carpenters. Recruitment was limited to males as the proportion of female members was too low to provide sufficient matches of cases and non-cases.

Cases were recruited through mailings, automated phone messages, and live telephone calls by the research team. All cases who indicated interest in the study were called by a member of the research team to provide a description of the study, to check eligibility criteria, to obtain consent, and to complete the telephone survey for the study. Cases were excluded if their CTS diagnosis resulted from an injury/traumatic event, if they indicated that they had never been diagnosed with or treated for CTS and did not recall seeing a doctor at any time for pain or numbness in their hands or fingers, had never been a carpenter or floor layer for the union, were not employed at the time their claim was filed, or if they were older than 70 years at the time of the survey. Cases had to be eligible for benefits at the time their claim was filed, but did not still have to be in the union or benefits eligible at the time of the survey. A total of 1024 CTS cases were identified by the benefits funds; 235 cases could not be contacted by the research team (no contact information available or no response), 449 refused to participate, and 95 were determined to be ineligible. A total of 245 cases completed the telephone survey and were available for the analysis.

After case surveys were completed, up to 3 non-cases were identified to match each case's trade, age within 5 years, and eligibility for benefits during the same month that the matched case's CTS claim was filed. Recruitment procedures of non-cases were identical to those used to recruit cases, including mailings, automated phone messages, and live phone calls. Non-cases were excluded if they were ever diagnosed with or treated for CTS, indicated that they had never been a carpenter or floor layer for the union, or if they were older than 70 years at the time of the survey. A total of 1659 potential non-cases who matched to case demographics were identified by the benefits fund; 668 could not be contacted by the

research team (no contact information available or no response), 570 refused to participate, and 62 were determined to be ineligible for the study (8 due to a potential diagnosis of carpal tunnel syndrome). A total of 339 non-cases completed the telephone survey and were available for the analysis.

All telephone surveys were completed between March 2011 and January 2014. Verbal consent was obtained from all study participants (cases and non-cases) prior to completing the telephone survey; after telephone surveys were completed, paper copies of the consent forms were mailed to all participants to obtain written documentation of consent. All participants were compensated for their participation in this study. The Institutional Review Board of Washington University provided the ethical approval for this study.

Matching criteria

A total of 245 cases and 339 non-cases completed the survey and met all inclusion criteria for the analysis. N on-cases were matched to cases for data analysis via random selection based on the following criteria: 1) age within 2 years, 2) members of the same trade union, and 3) actively working and eligible to file an injury claim within one month of the matched case's CTS claim date. These match criteria resulted in 234 matched pairs. Of the remaining unmatched non-cases, 15 were found to meet match criteria for 1 or more cases. These additional non-cases were added to 15 of the matched pairs via random selection using the same match criteria, resulting in a total of 234 cases matched with 249 non-cases.

Data collection

Survey measures—All participants (cases and non-cases) completed a telephone survey which captured information on demographics, current job/work status, medical history, general health, hand and finger symptoms, and work and functional abilities. Hand and finger symptoms were assessed using the following item based on the Nordic questionnaire (Kuorinka, et al., 1987): "In the past year, have you had RECURRING (repeated) symptoms with your HANDS or FINGERS more than **3** times or lasting more than ONE week?" Participants with positive reports of symptoms were also asked to rate the severity of their symptoms on a scale from 0 "no discomfort" to 10 "worst imaginable discomfort." The questionnaire also assessed several work outcomes related to hand/finger symptoms using items from the University of Michigan Upper Extremity Questionnaire such as changes in production rates and/or quality of work (Franzblau, et al., 1997, Salerno, et al., 2001).

Standardized functional outcome measures included 1-year recall modified versions of the Work and Hobby modules of the Disabilities of the Arm, Shoulder, and Hand (DASH) Outcome Measure (Hudak, et al., 1996), a modified recall version of the Functional Status Scale (FSS) from the Boston Carpal Tunnel Questionnaire (Levine, et al., 1993), the first two items from the Work Ability Index (rating of current work ability, and work ability in relation to job demands) (Ilmarinen and Tuomi, 1992, Tuomi, et al., 1998), and the Short form- 8 Health Survey (SF-8) (Ware, et al., 2001). The modified instructions and recall period for the DASH Work and Hobby modules and Levine FSS have been described previously in our prior publications (Dale et al., 2015, Gardner et al., 2015). All measures

were scored according to the developers' guidelines. The SF-8 was scored to yield the physical and mental component scores (Ware, et al., 2001).

In addition to reporting on symptoms and work and functional outcomes in the past year, cases were also asked to recall their functional abilities around the time of their CTS diagnosis. Collecting outcomes on multiple recall periods allowed us to assess whether functional abilities of CTS cases improved or impairments persisted over time. Cases also answered questions regarding their CTS claim including whether surgery or any other treatments were received.

Administrative data—Limited administrative data records were available for all benefits fund members who filed medical claims for musculoskeletal disorders between 2003 and 2011. Complete records were not available for years prior to 2003 due to the conversion of paper to electronic data records by the benefits funds. The administrative data included dates of member eligibility, date of medical claims and dates of procedures given to members, and records of members' monthly work hours.

Data Analysis

Descriptive statistics were calculated to describe the study population and to verify similarity of cases and non-cases on key demographic variables. We compared cases and non-cases on work and functional impairment outcomes using univariate regression models, with random intercepts to control for matching. Dichotomous outcomes were analyzed with binary logistic regression. Ordinal outcomes were analyzed with ordinal logistic regression, with results expressed as the odds of a CTS case having at least a 1-point higher ordered response than their matched non-cases. Continuous outcomes were analyzed with linear regression models, from which model coefficients and *p*-values are reported. Subjects with missing data were excluded from the respective models.

Next, we analyzed the effects of surgical versus non-surgical treatment for CTS on functional and work outcomes. We compared cases who self-reported receiving surgical treatment for CTS and cases who did not have surgery to non-cases in a single regression model for each outcome. These models produced two odds ratios for each outcome, one for surgical cases compared to their matched non-cases and one for non-surgical cases compared to their matched non-cases.

Using work hours from the administrative data records, we compared monthly work hours between cases and non-cases, to determine if cases experienced a loss of work hours in the months and years prior to the CTS medical claim date and/or after the claim date. We used linear regression models to compare work hours between cases and non-cases for the six-month and one-year periods before and after each case's CTS claim date, as well as for the second and third year following the claim. Similar to previous analyses, we also assessed the effects of self-reported surgical status on work hours by comparing surgical cases and non-surgical cases to non-cases in a single regression model for each time period.

Among CTS cases, we examined change on symptom and functional impairment outcomes over time comparing the time around the CTS diagnosis to the most recent year. We also

assessed whether there was a relationship between the time elapsed since CTS diagnosis and change in functional outcomes using Pearson's correlations. Next, we separated cases by self-reported surgical status to determine if there was a differential change in functional outcomes over time based on the treatment received. Changes on symptom and functional outcomes over time were compared graphically and via Student's t-tests, analyzing surgical and non-surgical cases separately. We also compared surgical cases with non-surgical cases on each outcome measure for each recall period, around the time of diagnosis and in the past year.

We also analyzed the effects of age (50 years or older versus younger than 50), comorbid medical conditions (diabetes, rheumatoid arthritis, osteoarthritis, and/or gout), and bilateral versus unilateral CTS on functional impairment and work outcomes among CTS cases. We compared cases based on age, comorbidities, and bilateral versus unilateral CTS on the FSS and DASH Work Module using Student's t-tests. We hypothesized that among CTS cases, functional outcomes would be worse for older cases and for those with comorbid medical conditions.

Finally, we assessed the healthy worker effect among the CTS cases in our cohort by comparing participants and non-participants on age and whether they were actively working at the end of the available administrative data on work hours.

RESULTS

Two hundred thirty-four cases and 249 matched non-cases were included in the analysis. Eight of the cases were floor layers and the rest were carpenters. Telephone interviews with CTS cases were conducted a mean of 5.0 years (range 2.2–9.0 years) after the CTS medical claim was filed. Approximately 70% of cases had bilateral CTS. Demographic characteristics of the cases and non-cases were similar in the distribution of race, employment status, and the mean number of years worked in their respective trades (Table I). There was no difference in the mean age between cases and non-cases, although the proportion of workers in the oldest age category (61–70 years) at the time of the survey was higher among non-cases than cases; in addition, a higher proportion of non-cases were retired at the time of survey than cases. There was a higher prevalence of osteoarthritis and rheumatoid arthritis among cases versus non-cases. The proportion of workers in the two oldest age categories (51–60 years, and 61–70 years) at the time of the survey was higher among cases that underwent surgery than non-surgical cases. In addition, a higher proportion of non-surgical cases were still working at the time of the survey, whereas more surgical cases were retired and unemployed. A higher proportion of surgical cases had bilateral CTS versus non-surgical cases (77.2% versus 63.6%).

Comparison of cases and non-cases on survey measures

Table II shows the results of comparisons of cases and non-cases on self-reported symptom and functional outcomes. Compared to matched non-cases, cases with a past medical claim for CTS were more likely to report recurrent hand symptoms in the past year (OR 2.24, 95% CI 1.54, 3.24), decreased production rates or quality of work performed due to symptoms (OR 2.37, 95% CI 1.52, 3.68), and decreased ability to perform the physical demands of

their work (OR 1.59, 95% CI 1.13, 2.24). Cases also reported significantly greater functional limitations of the upper extremity as measured by the FSS and by the DASH Work and Hobby modules. When compared to unilateral CTS cases, bilateral cases showed significantly greater functional limitations and greater symptom severity (data not shown).

When CTS cases were separated by surgical status (Table III), cases who did not have surgery were more likely to report recurring hand symptoms in the past year (OR 4.18, 95% CI 2.54, 6.89) and decreased work production rates or work quality (OR 3.30, 95% CI 2.01, 5.43) compared to non-cases, however, these associations were not found for cases that had surgery.

Comparison of work hours among cases and non-cases

Comparison of monthly work hours among cases and non-cases showed no statistically significant differences in work hours in the 6-month and 1-year periods preceding the cases' CTS claim dates(Table II); however, surgical cases tended to have fewer work hours for both time periods prior to their claim date versus their matched non-cases (Table III), whereas non-surgical cases had slightly higher work hours than their matched non-cases, although these differences were not statistically significant. When we examined total monthly work hours in the 6-month and 1-year periods following the CTS claim date comparing all CTS cases to all non-cases in our study, the absolute differences in monthly work hours were modest (−2.50 and −3.38 hours lost, respectively) and were not statistically significant (Table II). When we separated CTS cases by surgical status, surgical cases showed greater loss of work hours in the 6-month (−16.50 hours) and 1-year (−15.85 hours) periods following their claim date versus non-cases; whereas non-surgical cases showed no statistically significant differences in total monthly work hours versus non-cases for the same time periods (4.17 and −0.26 hours, respectively)(Table III). When we further explored the timing of the work loss for the surgical cases in our study, the period of loss was concentrated in the months immediately following the date of surgery.

Change in functional outcomes among CTS cases over time

Figure 1 shows the change of symptoms and functional outcomes among CTS cases over time, with CTS cases separated by surgical treatment status. There was no correlation between time elapsed since CTS diagnosis and change over time. At the time of diagnosis, cases who underwent surgery reported significantly worse impairment than non-surgical cases on symptom severity ratings ($p<0.001$), the FSS ($p<0.001$), DASH Work module ($p<0.001$), and DASH Hobby module ($p=0.042$). Comparing the time around diagnosis to the most recent year, both surgical and non-surgical cases showed statistically significant improvements ($p<0.05$) on all outcomes, with the exception of the non-surgical cases showing only minimal improvement on the FSS ($p=0.113$). With the exception of significantly higher symptom severity ratings among the non-surgical cases ($p<0.001$), there were no statistically significant differences between surgical and non-surgical cases on functional outcomes for the past year recall period.

Effects of age, comorbidities, and bilateral versus unilateral CTS on functional outcomes

Among CTS cases, there were no effects of age on functional impairment outcomes for the 1-year recall period. Cases with comorbid medical conditions showed more impairment than cases with no comorbidities on the FSS (mean 2.3 versus 2.0, p=0.01) and DASH Work module (mean 30.4 versus 25.6, p=0.01). Cases with bilateral CTS showed more functional impairment versus cases with unilateral CTS on the FSS (mean 2.2 versus 1.8, p=0.0039) and DASH work module (mean 30.1 versus 19.5, p=0.0110).

Comparison of participant and non-participant CTS cases

We compared the demographics of participants (n=217) and non-participants (n=558), for 76% of the 1024 workers with CTS claims recorded in the database who had data available for this analysis. Our results showed that non-participants were younger at the time their CTS claim was filed (mean 41.72 years versus 43.78 years, p=0.0107) and a greater proportion of them had stopped logging work hours by January 1, 2011 (46.2% versus 35.9%, p=0.012).

DISCUSSION

The results of this study indicate that union construction workers with CTS from 2003 through 2010 reported a higher prevalence of recurring hand symptoms and decreased functional and work abilities than matched non-cases without CTS. CTS cases experienced prolonged disability and persistent symptoms for many years following their diagnosis; cases who underwent surgery had larger improvements on multiple outcomes than non-surgical cases. Despite the functional impairments observed among the CTS cases, minimal changes in paid work hours were seen between CTS cases and non-cases in the years preceding and following the cases' CTS medical claim dates.

Few studies of long-term functional outcomes related to CTS have focused on working populations, despite the higher prevalence and incidence of CTS and CTS symptoms than general populations (Armstrong, et al., 2008, Forde, et al., 2005, Franklin, et al., 1991, Rosecrance, et al., 2002). Manktelow et al. assessed 4-year outcomes of all Ontario workers who were diagnosed with CTS and missed work due to treatment in 1996 (n=964) (2004). This study showed that workers with CTS had a 50% chance of having moderate to severe pain and numbness and a 50% chance of having difficulty performing activities of daily living and recreational activities 4 years after treatment (Manktelow, et al., 2004). Our study also showed high rates of recurring hand symptoms among CTS cases (67%) an average of 5 years after diagnosis. However, symptoms were also common among non-cases without CTS (48%). Having a matched comparison population of workers without CTS allowed us to determine the extent to which these symptoms could be attributed to CTS (adjusted OR 2.2, 95% CI 1.5–3.2). Workers in the Ontario study also showed residual disability years following CTS treatment, with scores ranging from 2.03 (unilateral CTS) to 2.16 (bilateral CTS) on the Levine FSS, similar to the level of functional disability reported by all CTS cases in our cohort (mean 2.06) in the year preceding the study survey. This functional disability experienced by CTS cases in our cohort was significantly worse than that among the non-cases (mean 1.4, $p<0.001$).

CTS cases in our study who underwent surgery showed larger improvements in symptom severity ratings and functional abilities as measured by the Levine FSS, DASH Work and Hobby modules, versus non-surgical CTS cases.; However, surgical cases reported greater severity of symptoms that was likely associated with greater impairment on all outcomes around the time of their CTS diagnosis than non-surgical cases, and thus had more potential for improvement. Previous studies of clinical CTS patients comparing surgical and non-surgical treatment have shown the effectiveness of surgical treatment for improving symptom and functional outcomes in relation to CTS (Cagle, et al., 2014, Keith, et al., 2009, Louie, et al., 2012); patients may also improve without surgery, but generally less so than surgical cases (Padua, et al., 2001, Pensy, et al., 2011, Resende, et al., 2003). Limitations of previous studies have included a lack of studies in working populations rather than general or treatment-seeking populations, lack of non-surgical and normal matched comparison groups, short follow-up periods, and limited use of functional outcomes measurement to augment clinical measures such as symptoms, physical exam findings or electrodiagnostic findings. Despite the improvements in symptom and functional outcomes over time among both surgical and non-surgical CTS cases, neither case group improved to the same level as non-cases.

The loss of work hours seen among the CTS cases in our cohort versus matched non-cases was considerably lower than time loss estimates that have been reported in previous studies of workers seeking treatment for CTS under workers' compensation (Daniell, et al., 2005, Daniell, et al., 2009, Spector, et al., 2012, Turner, et al., 2007). Similar to our findings of greater loss of work hours among surgical cases in the 6-month and 1-year periods following their CTS claim dates, Daniell et al. showed that among all workers' compensation CTS claims filed between 1990–1994 in Washington State, workers who underwent CTS surgery experienced slightly more time loss; although when the analysis was restricted to workers who had at least 1 month duration of disability, surgical cases showed a lower total duration of disability (2009). As Daniell et al. explained, some amount of work loss following surgery is likely inevitable to allow for post-surgical recovery (2009). Although not statistically significant, the surgical cases in our study continued to see fewer work hours in years 2 and 3 post-claim.

One distinction between our study population and these previous studies is that the CTS claims for the workers in our study were filed under personal health insurance and not through the workers' compensation system, thus no wage replacement for time loss due to CTS was received under workers' compensation. Construction workers enrolled in benefits plans under the Taft-Hartley Act may lose insurance eligibility if they are off work for an extended period of time following an injury. Thus, workers with CTS claims filed under their personal insurance may have more of an incentive to return to work than workers treated within the workers' compensation system, despite residual functional impairment. Underreporting of work related injuries and illnesses, particularly chronic musculoskeletal disorders, is very common among construction workers, and many claims are likely shifted to personal health insurance (Dale, et al., 2015, Lipscomb, et al., 2015, Welch, et al., 2007). Our past studies of workers with hand wrist symptoms and CTS have shown that many workers report significant pain and functional impairment but remain at work (Gardner et al., 2014). Particularly in construction trades there is a reluctance to miss work given the

episodic nature of employment and the perception that lost work due to injury will threaten future employment (Dong, et al., 2011, Glazner, et al., 1998, Probst, et al., 2008, Welch, et al., 2007).

This study had several limitations. Survey data may be subject to both differential and non-differential recall bias; however, many of the functional outcomes of interest in this study could only be obtained by self-report. We supplemented the self-reported outcomes data by examining the economic impact of CTS on construction workers using work hours from the administrative data records. We were unable to compare function in cases and non-cases around the time of CTS diagnosis because non-cases did not have a specific event to recall. Our case definition for CTS was based on administrative records alone rather than on detailed medical records or electrodiagnostic findings, so we were unable to verify the supporting medical information (symptoms, medical history) that led to the CTS diagnoses. In the aforementioned study by Manktelow et al., there was greater certainty of a true CTS diagnosis among the workers who underwent surgery (86%) versus those who did not (70%) (2004). During study recruitment, we excluded cases who did not recall being diagnosed with CTS or seeing a doctor for pain or numbness in their hands or fingers in order to improve the diagnostic certainty of CTS. It is possible that this procedure could have eliminated less severe cases and resulted in the ascertainment of more severe cases of CTS. We believe that it is more likely that a selection bias occurred in the opposite direction due to severely symptomatic workers leaving the workforce. We explored the possibility of such a healthy worker survivor effect among our cohort by examining carpenters with a medical claim for CTS who participated or did not participate in our study. Non-participants had CTS claims at an earlier age, and were more likely to have left the workforce, suggesting that there is a healthy worker survivor effect in our study population. If so, our study findings likely *underestimate* the long-term functional limitations seen among workers with a history of CTS as the more severe cases were not interviewed. Finally, our study population included workers from only 2 trades (carpenters and floor layers) who were union members with health benefits. Thus our study population may not be representative of all construction trades nor of non-union workers without access to union sponsored health coverage. It is quite possible that functional and employment outcomes may have been even worse among non-union construction workers.

Despite these limitations, our study is one of the few to have assessed long-term functional outcomes in relation to CTS. Only one small previous study (47 CTS cases) included a matched comparison population (Gorsche, et al., 2002). Such a comparison is important in order to assess the degree to which work and functional outcomes can be attributed to CTS, rather than to the background rates of disability in a working population. In addition, few studies of CTS and other upper extremity musculoskeletal disorders have focused on construction workers despite their high risk of CTS versus other working populations.

Conclusions

Few studies have examined the natural course and health impact of CTS in workers, especially among high risk populations such as construction workers. The results of this study show that persistent hand symptoms and functional impairments may be present for

years following CTS diagnosis. The cost of this prolonged impairment and disability to workers, employers, and to society as a whole is unmeasured. Time loss from work is an insensitive measure of disability as prolonged symptoms and functional impairment persist for many years. Additional studies of long-term functional and work outcomes of CTS and other musculoskeletal disorders are needed to improve prevention efforts and treatment options.

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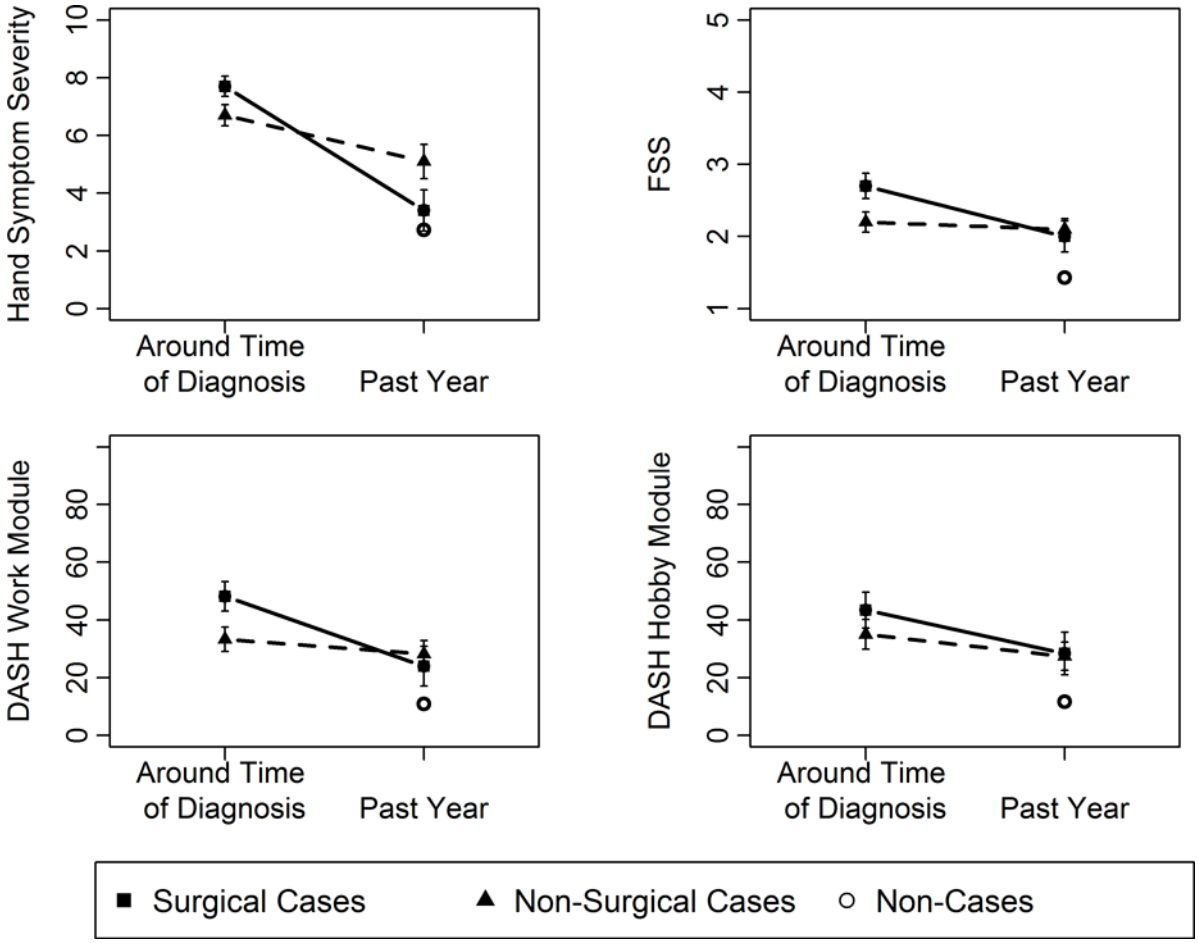

Fig 1.

Change over time in symptoms and functional outcomes among CTS cases treated surgically and non-surgically.

FSS - Functional Status Scale; DASH - Disabilities of the Arm, Shoulder, and Hand Outcome Measure

Table I

Demographic characteristics of surgical and non-surgical CTS cases and matched non-cases

Characteristic	Surgical cases (n=105)	Non- surgical cases (n=129)	All Cases (n=234)	Non cases (n=249)
Age, years, mean (SD)	50.1 (9.9)	48.3 (10.8)	49.1 (10.4)	50.1 (11.0)
Age, years, n (%)				
≤ 40	17 (16.2)	32 (24.8)	49 (20.9)	53 (21.3)
41–50	27 (25.7)	36 (27.9)	63 (26.9)	60 (24.1)
51–60	46 (43.8)	45 (34.9)	91 (38.9)	91 (36.5)
61–70	15 (14.3)	16 (12.4)	31 (13.2)	45 (18.1)
Race, n (%)				
White	105 (100)	122 (94.6)	227 (97.0)	238 (95.6)
Retired	16 (15.2)	11 (8.5)	27 (11.5)	45 (18.1)
Still working	62 (59.1)	90 (69.8)	152 (65.0)	148 (59.4)
Unemployed	27 (25.7)	28 (21.7)	55 (23.5)	56 (22.5)
Age at retirement, mean (SD)	58.8 (5.7)	59.8 (4.3)	59.2 (5.1)	59.1 (3.4)
Years in trade, mean (SD)	28.3 (10.4)	25.9 (11.4)	27.0 (11.0)	27.9 (12.1)
Diabetes, n (%)	7 (6.7)	6 (4.7)	13 (5.6)	16 (6.4)
Rheumatoid arthritis, n (%)	8 (7.6)	8 (6.2)	16 (6.8) *	6 (2.4) *
Osteoarthritis, n (%)	22 (21.0)	21 (16.3)	43 (18.4) *	22 (8.8) *
Years since CTS claim filed, mean (range)	5.2 (2.3 – 9.0)	4.9 (2.2 – 8.9)	5.1 (2.2 – 9.0)	N/A
CTS Diagnosis by side, n (%)				
Bilateral CTS	81 (77.2)	82 (63.6)	163 (69.6)	N/A
Unilateral CTS				N/A
Dominant hand	18 (17.1)	29 (22.5)	47 (20.1)	N/A
Non-dominant hand	6 (5.7)	15 (11.6)	21 (9.0)	N/A
Unknown	0 (0)	3 (2.3)	3 (1.3)	N/A

CTS, carpal tunnel syndrome, SD standard deviation

* $p<0.05$

Table II

Comparison of cases and non-cases on functional outcomes (in the past year)

	Cases (n=234)		Non-cases (n=249)		Regression estimates	
Binary Outcome	**valid n**	**n (%)**	**valid n**	**n (%)**	**Odds ratio[#]**	**95% CI**
Recurring hand symptoms in past year	234	157 (67.1)	249	119 (47.8)	2.24	(1.54 – 3.24)
Ordinal Outcome		**mean (SD)**		**mean (SD)**	**Odds ratio[#]**	**95% CI**
Symptoms interfered with production rates and/or quality of work in the past 4 weeks, (1–5 scale)[&]	163	3.8 (1.5)	172	4.3 (1.2)	2.37^	(1.52 – 3.68)
Symptoms are caused by or made worse by work activities, (1–5 scale)[&]	155	1.7 (1.2)	118	2.0 (1.3)	1.68^	(1.04 – 2.71)
Work ability related to physical job demands, (1–5 scale)[†]	212	2.1 (1.1)	249	1.8 (1.0)	1.59~	(1.13 – 2.24)
Continuous Outcome	**valid n**	**mean (SD)**	**valid n**	**mean (SD)**	**Beta[#Δ]**	***p***
Functional Status Scale, (1–5 scale)[†§]	203	2.1 (0.9)	249	1.4 (0.6)	0.62	<0.001
DASH Hobby Module, (range 0–100)[† §]	187	27.8 (28.5)	247	11.6 (20.4)	16.19	<0.001
DASH Work Module, (range 0–100)[† §]	169	26.7 (25.4)	203	10.9 (18.2)	15.76	<0.001
SF-8 Physical[‡]	232	46.7 (9.6)	246	49.1 (9.3)	−2.37	0.007
SF-8 Mental[‡]	232	50.5 (10.6)	246	53.4 (7.0)	−2.89	<0.001
Work ability rating (range 0–10)[‡]	213	7.8 (2.6)	249	8.4 (2.3)	−0.63	0.006
Total monthly work hours description						
1 year pre-claim	232	122.6 (44.4)	249	124.2 (46.8)	−2.50	0.595
6 months pre-claim	232	125.6 (46.6)	249	130.7 (47)	−3.38	0.495
6 months post-claim	232	120.7 (51.5)	249	129.8 (48)	−5.03	0.354
1st year post-claim	232	115 (50.4)	249	123.8 (50.5)	−7.20	0.159
2nd year post-claim	232	107.7 (53.5)	249	119 (54.2)	−7.62	0.121
3rd year post-claim	232	107.2 (54.8)	249	112.6 (53.9)	−5.94	0.219

CI confidence interval, SD standard deviation

[#]adjusted for match groups via random intercepts in all models

[&]1=strongly agree with statement, 5= strongly disagree with statement

^ Odds ratio from ordinal logistic regression that expresses the likelihood of having at least a 1 point greater agreement with the statement than the reference.

† Higher score indicates worse outcome

‡ Lower score indicates worse outcome

~ Odds ratio from ordinal logistic regression that expresses the likelihood of having at least a 1 point worse response than the reference.

Δ Beta denotes the estimated mean difference between the case and non-case

§ Modified 1-year recall period

Table III

Comparison of surgical and non-surgical CTS cases to their matched non-case on functional outcomes and monthly work hours

Binary Outcome	**n (%)**	**Odds ratio[#]**	**95% CI**
Recurring hand symptoms in past year			
Non-cases (n=249)	119 (47.8)	reference	reference
Cases: surgical (n=105)	55 (52.4)	1.20	(0.75 – 1.91)
Cases: non-surgical (n=129)	102 (79.1)	4.18	(2.54 – 6.89)
Ordinal Outcome	**mean (SD)**	**Odds ratio[#]**	**95% CI**
Symptoms interfered with production rates and/or quality of work in the past 4 weeks, (1–5 scale)[&]			
Non-cases (n=172)	4.3 (1.2)	reference	reference
Cases: surgical (n=63)	4.2 (1.4)	1.29[^]	(0.70 – 2.38)
Cases: non-surgical (n=100)	3.5 (1.5)	3.30[^]	(2.01 – 5.43)
Symptoms are caused by or made worse by work activities, (1–5 scale) [&]			
Non-cases (n=118)	2.0 (1.3)	reference	reference
Cases: surgical (n=55)	1.87 (1.39)	0.65[^]	(0.34 – 1.25)
Cases: non-surgical (n=100)	1.67 (1.14)	1.76[^]	(1.02 – 3.01)
Work ability related to physical job demands, (1–5 scale)[†]			
Non-cases (n=249)	1.8 (1.0)	reference	reference
Cases: surgical (n=96)	2.2 (1.4)	1.8[~]	(1.16 – 2.80)
Cases: non-surgical (n=116)	2.0 (0.9)	0.7[~]	(0.45 – 1.03)
Continuous Outcome	**mean (SD)**	**Beta[#Δ]**	***p***
Functional Status Scale (range 1–5)[†§]			
Non-cases (n=249)	1.4 (0.6)	reference	reference
Cases: surgical (n=84)	2.0 (1.0)	0.58	0.000
Cases: non-surgical (n=119)	2.1 (0.8)	0.65	0.000
DASH Hobby Module (range 0–100)[†§]			
Non-cases (n=247)	11.6 (20.4)	reference	reference
Cases: surgical (n=76)	28.4 (32.3)	16.76	0.000

Binary Outcome	n (%)	Odds ratio[#]	95% CI
Cases: non-surgical (n=111)	27.4 (25.8)	15.81	0.000
DASH Work Module (range 0–100)[†§]			
Controls (n=203)	10.9 (18.2)	reference	reference
Cases: surgical (n=62)	24.0 (27.2)	13.12	0.000
Cases: non-surgical (n=107)	28.2 (24.3)	17.29	0.000
SF-8 Physical[‡]			
Non-cases (n=246)	49.1 (9.3)	reference	reference
Cases- surgical (n=105)	45.6 (11.0)	−3.41	0.002
Cases- non-surgical (n=127)	47.6 (8.3)	−1.51	0.145
SF-8 Mental[‡]			
Non-cases (n=246)	53.4 (7.0)	reference	reference
Cases: surgical (n=105)	50.9 (11.1)	−2.50	0.017
Cases: non-surgical (n=127)	50.2 (10.2)	−3.21	0.001
Work ability rating (range 0–10)[‡]			
Non-cases (n=249)	8.4 (2.3)	reference	reference
Cases: surgical (n=96)	7.6 (3.0)	−0.81	0.006
Cases: non-surgical (n=117)	7.9 (2.3)	−0.48	0.083
Total monthly work hours description			
1 year pre-claim			
Non-cases (n=249)	124.2 (46.8)	reference	reference
Cases: surgical (n=103)	117.9 (45.3)	−11.16	0.006
Cases: non-surgical (n=129)	126.1 (43.5)	4.44	0.036
6 months pre-claim			
Non-cases (n=249)	130.7 (47)	reference	reference
Cases: surgical (n=103)	122.2 (45)	−11.51	0.012
Cases: non-surgical (n=129)	128.1 (47.8)	3.13	0.100
6 months post-claim			
Non-cases (n=249)	129.8 (48)	reference	reference
Cases: surgical (n=103)	111.6 (53.5)	−16.50	0.003
Cases: non-surgical (n=129)	127.6 (49.1)	4.17	0.087

Binary Outcome	n (%)	Odds ratio[#]	95% CI
1st year post-claim			
Non-cases (n=249)	123.8 (50.5)	reference	reference
Cases: surgical (n=103)	106.7 (51.7)	−15.85	0.002
Cases: non-surgical (n=129)	121.3 (48.7)	−0.26	0.081
2nd year post-claim			
Non-cases (n=249)	119 (54.2)	reference	reference
Cases: surgical (n=103)	103.7 (57.3)	−8.92	0.016
Cases: non-surgical (n=129)	110.8 (50.3)	−6.58	0.024
3rd year post-claim			
Non-cases (n=249)	112.6 (53.9)	reference	reference
Cases: surgical (n=103)	104.9 (55.6)	−11.04	0.098
Cases: non-surgical (n=129)	108.8 (54.4)	−1.88	0.755

CI confidence interval, SD standard deviation

[#] adjusted for match groups via random intercepts in all models

[&] 1=strongly agree with statement, 5= strongly disagree with statement

[^] Odds ratio from ordinal logistic regression that expresses the likelihood of having at least a 1 point greater agreement with the statement than the reference.

[†] Higher score indicates worse outcome

[‡] Lower score indicates worse outcome

[~] Odds ratio from ordinal logistic regression that expresses the likelihood of having at least a 1 point worse response than the reference.

[Δ] Beta denotes the estimated mean difference between the case and non-case

[§] Modified 1-year recall period