National Trends in the Diagnosis of CRPS after Open and Endoscopic Carpal Tunnel Release

Kevin Mertz, BS¹ Jeremy Trunzter, MD¹ Edward Wu, MD¹ James Barnes, MD, MS²
Sara L. Eppler, MPH¹ Robin N. Kamal, MD¹

¹ Department of Orthopaedic Surgery, Stanford University, Redwood City, California

² VA Palo Alto Health Care System, Center for Health Policy/Primary Care Outcomes Research, Stanford University, Palo Alto, California

Address for correspondence Robin Kamal, MD, Department of Orthopaedic Surgery, Stanford University Medical Center, 450 Broadway Street, MC: 6342, Redwood City, CA 94063 (e-mail: rnkamal@stanford.edu).

J Wrist Surg 2019;8:209–214.

Abstract

Background Complex regional pain syndrome (CRPS) occurs in 2 to 8% of patients that receive open or endoscopic carpal tunnel release (CTR). Because CRPS is difficult to treat after onset, identifying risk factors can inform prevention. We determined the incidence of CRPS following open and endoscopic CTR using a national claims database. We also examined whether psychosocial conditions were associated with CRPS after CTR.

Methods We accessed insurance claims using diagnostic and procedural codes. We calculated the incidence of CRPS following open carpal tunnel release and endoscopic carpal tunnel release within 1 year. The response variable was the presence of CRPS after CTR. Explanatory variables included procedure type, age, gender, and preoperative diagnosis of anxiety or depression.

Results The number of open CTRs (85% of total) outweighs the number of endoscopic procedures. In younger patients, the percentage of endoscopic CTRs is increasing. Rates of CRPS are nearly identical between surgery types for both privately insured (0.3%) and Medicare patients (0.1%). Middle aged (range: 40–64 years) and female patients had significantly higher rates of CRPS than did the general population. Preoperative psychosocial conditions did not correlate with the presence of CRPS in surgical patients.

Clinical Relevance The decision between endoscopic and open CTR should not be made out of concern for development of CRPS postsurgery, as rates are low and similar for both procedures. Rates of CRPS found in this study are much lower than rates found in previous studies, indicating inconsistency in diagnosis and reporting or generalizability of prior work. Preoperative psychosocial disorders and CRPS are unrelated.

Keywords

- carpal tunnel release
- carpal tunnel syndrome
- complex regional pain syndrome
- quality

Complex regional pain syndrome (CRPS) is a disease of the sympathetic nervous system that that can result in pain, abnormal blood shunting, subcutaneous edema, and motor dysfunction.^{1–3} The incidence of CRPS in hand surgery is highly variable in the literature. For example, prior studies have estimated the posttreatment incidence of CRPS to occur in approximately 7% of all limb fracture procedures.⁴ In hand and wrist arthroplasty and fracture repair, rates of CRPS have

ranged from 2 to 40%, depending on the type of injury.^{5–8} Although the mechanism of CRPS is not fully understood, psychosomatic factors may also contribute to the development and severity of CRPS.¹ Unfortunately, sustained improvement in symptoms is rare and difficult to maintain. Early diagnosis and prevention remains critical for a successful outcome.^{2,9}

There are an estimated 600,000 carpal tunnel releases (CTR) performed annually in the United States.¹⁰ Buller et al reviewed

received

April 18, 2018

accepted after revision

January 7, 2019

published online

February 27, 2019

Copyright © 2019 by Thieme Medical Publishers, Inc., 333 Seventh Avenue, New York, NY 10001, USA.
Tel: +1(212) 584-4662.

DOI <https://doi.org/10.1055/s-0039-1678674>.
ISSN 2163-3916.

single center studies on CRPS development after CTR and reported an average rate of 8.3%.¹¹ Da Costa et al reported CRPS rates of 2 to 5% in their analysis of different anesthesia techniques for CTR.¹² These studies are limited to single institutions and fail to distinguish between the two different methods of CTR, open or endoscopic. Reviews by Chen et al and Sayegh and Strauch attempted to elicit differences in the two techniques and found that major complication rates, including CRPS, did not vary significantly.^{13,14} Other attempts to compare complication rates of the open and endoscopic techniques have been similarly inconclusive, as a meta-analysis by Kohanzadeh et al found that complications were the only outcome in which the two techniques did not vary.¹⁵ There is limited literature from multiple centers that compares CRPS rates after open and endoscopic CTR.^{13,14}

Current patient factors that correlate with the development of CRPS are difficult to detect and diagnose (i.e., abnormal brain structure and altered signaling pathways).^{16,17} Discovering detectable comorbidities that are correlated with CRPS could help inform interventions to prevent the development of CRPS. Because of the disease's potential psychosomatic roots, depression and anxiety disorders may be more prevalent in patients that develop CRPS.¹⁸ Indeed, Rewhorn et al found that foot and ankle surgical patients with a history of depression were more likely to develop CRPS.¹⁹ With these disorders in mind, we used private and Medicare insurance claims to perform a nationwide analysis of the rates of CRPS after open and endoscopic CTR. We then analyzed the patient populations to determine whether the presence of depression or anxiety correlated with the development of CRPS.

Methods

Data

Patients for this study were identified using the Pearl Diver patient record databases for Humana and Medicare. The database contains 22 million patient diagnosis and procedural records from 2007 to 2016 from across the United States. To sort patient diagnoses and procedures, International Classification of Disease, 9th Edition (ICD-9) and Current Procedural Terminology (CPT) diagnosis and procedure codes were used.

Cohorts

Patients with carpal tunnel syndrome (ICD-9-D-3540), undergoing endoscopic or open carpal tunnel release (CPT-29848 and CPT-64721, respectively), were divided into two cohorts. Patients with the diagnosis of CRPS (ICD-9-D-33721 and ICD-9-D-3544) within 1 year of the procedure were identified. Patients diagnosed with either rheumatoid arthritis (ICD-9-D-7140), osteoarthritis (ICD-9-D-71514), or patients with upper extremity fractures were excluded from both procedure groups (codes in ►Fig. 1). The two patient populations were then broken down by age and gender.

Additionally, patients were further subcategorized based on the presence of depression (ICD-9-D-311) or anxiety (ICD-9-D-3004) within the 5 years before their CTR procedure (►Fig. 1).

Fig. 1 Pearl Diver command methodology with associated ICD-9, CPT, and Physpec codes. Exclusion diagnoses listed as well. CPT, Current Procedural Terminology; CRPS, complex regional pain syndrome; CTR, carpal tunnel release; ICD-9, International Classification of Disease, 9th Edition.

Variables and Statistical Analysis

Demographic variables including age and gender were evaluated in patients who developed CRPS within 1 year of open or endoscopic CTR. Explanatory variables included the type of CTR (open or endoscopic), age, gender, preoperative depression or anxiety. The outcome variable was the diagnosis of CRPS. Yearly trends of CTR and CRPS were also reported.

We performed a two-tail binomial proportion test to assess for significant differences in postoperative incidence of CRPS between open and endoscopic surgical types. We also used binomial proportion testing to evaluate for significant differences between the incidence of postoperative CRPS in the total population and various population subsets, including age groups, genders, and patients with preoperative depression and anxiety, independent of surgical type. Using rates of CRPS found in the Chen et al study on open and endoscopic CTR, our minimum population size to detect a 2% difference in CRPS rates is 1,536, with a power of 0.8.¹³ Statistical significance was set at $\alpha < 0.05$. Statistical analysis was performed using SAS software (University Edition, Version 3.6, Copyright 2012–2016, SAS Institute Inc., Cary, NC).

Approval from the Internal Review Board was not needed as all patient records were deidentified. No funding was used for this project.

Results

Female patients were found to have significantly higher rates of CRPS after both endoscopic and open CTR compared with male patients and the overall population. A total of 75 to 80% CRPS cases were in elderly patients (60–79 years) but CRPS rates were highest for middle aged patients (40–65 years) as fewer overall procedures were performed in this group. The rates of CRPS in younger patients were significantly higher for ages 45 to 64 for Humana and under 65 for Medicare when compared with the population overall.

Open CTR accounted for 85% of total procedures in both privately insured and Medicare patients (►Tables 1 and 2). Yearly trends for CTR for the Humana dataset (►Fig. 2) show

Table 1 Private insurance, endoscopic and open CTR with CRPS incidence

Humana	Endoscopic		Open	
	Total CTR	CTR with CRPS (with rate)	Total CTR	CTR with CRPS (with rate)
All patients	12,981	39 (0.003)	70,585	272 (0.004)
Gender				
Female	7,947	38 (0.005) ^a	42,256	192 (0.005) ^a
Male	5,034	13 (0.003)	28,329	80 (0.003)
Age (y)				
25–29	58	< 10	302	< 10
30–34	155	< 10	663	< 10
35–39	278	< 10	1,200	< 10
40–44	366	< 10	1,870	12 (0.006)
45–49	574	< 10	3,099	25 (0.008) ^a
50–54	937	< 10	4,703	31 (0.007) ^a
55–59	1,118	< 10	5,848	36 (0.006) ^a
60–64	1,062	< 10	6,141	34 (0.006) ^a
65–69	2,490	< 10	13,713	56 (0.004)
70–74	2,346	< 10	13,152	38 (0.003)
75–79	1,852	< 10	9,958	30 (0.003)
80–84	1,162	< 10	6,718	11 (0.002)
85–89	404	< 10	2,362	< 10
> 90	356	< 10	2,408	< 10
CRPS risks				
Depression	2,368	< 10	13,245	50 (0.004)
Anxiety	713	< 10	3,783	30 (0.003)

Abbreviations: CRPS, complex regional pain syndrome; CTR, carpal tunnel release.
Total repairs and CRPS rates for endoscopic and open CTR techniques. Rates given as decimals.
^aDesignated statistical significance.

Table 2 Medicare, endoscopic and open CTR with CRPS incidence

Medicare	Endoscopic		Open	
	Total CTR	CTR with CRPS (with rate)	Total CTR	CTR with CRPS (with rate)
All patients	85,261	139 (0.001)	567,685	981 (0.001)
Gender				
Female	51,499	92 (0.002)	343,873	627 (0.002)
Male	32,856	47 (0.001)	216,238	354 (0.002)
Unknown	926	< 10	8,079	29 (0.004) ^a
Age (y)				
≤64	14,210	53 (0.004) ^a	110,105	355 (0.003) ^a
65–69	19,545	36 (0.002)	120,189	214 (0.002)
70–74	17,106	28 (0.002)	107,357	201 (0.002)
75–79	15,252	12 (0.002)	100,949	140 (0.001)
80–84	11,625	11 (0.001)	80,590	84 (0.001)
≥85	8,083	< 10	56,866	44 (0.001)
Unknown	926	< 10	8,078	29 (0.004) ^a
CRPS risks				
Depression	12,168	20 (0.001)	85,817	125 (0.001)
Anxiety	3,448	159 (0.001)	26,922	98 (0.001)

Abbreviations: CRPS, complex regional pain syndrome; CTR, carpal tunnel release.

Note: Total repairs and CRPS rates for endoscopic and open CTR techniques. Rates are given as decimals.

^aDesignated statistical significance.

a steady increase in both open and endoscopic techniques. The CRPS rates with CTR similarly increased (►Fig. 3), with greater fluctuation. The yearly trends for the Medicare data (►Fig. 4) showed that the number of procedures has been relatively constant. The CRPS rates also stayed mostly level (►Fig. 5), with minor year-to-year fluctuation.

The binomial proportion analysis found that rates of CRPS did not vary significantly between surgery types ($p = 0.15$). Further proportion testing found that neither depression or anxiety had significant correlation with development of CRPS post-CTR.

Fig. 2 Year-by-year trends of open and endoscopic CTR, Humana data. CTR, carpal tunnel release.

Fig. 3 Year-by-year trends of open and endoscopic CTR with subsequent CRPS diagnosis, Humana (private insurance) data. CRPS, complex regional pain syndrome; CTR, carpal tunnel release.

Fig. 4 Year-by-year trends of open and endoscopic CTR, Medicare data. CTR, carpal tunnel release.

Discussion

CRPS has been reported to occur in 2 to 5% of patients that undergo CTR. The data come from single center studies that may lack generalizability to other populations. This study reports the national trends of CRPS following CTR to inform physicians of the CRPS risk between open and endoscopic CTR. By evaluating age, gender, and the presence of psychosocial disorders, we provide information on CRPS after CTR for several population subsets.

There was little correlation between CRPS development and any patient variables. However, female patients were significantly more likely to develop CRPS than males for all populations of both surgical types. Female patients received the majority of CTRs (60%) but still had significantly higher rates of CRPS. Past studies on the characteristics of CRPS also found that women were far more likely to develop CRPS in general,^{20–22} with estimates of three to four times that of men.⁵ Elderly patients (65–80 years) received the most CTR procedures (60–80% of total procedures). However, patients younger than 65 years old developed CRPS at significantly higher rates than elderly patients. This aligns with past investigations of CRPS, which demonstrated that middle age patients were the most susceptible to developing the condition.^{20,21} It is believed that these younger patients with CRPS experience a more aggressive form of the condition than do older patients, and therefore may be diagnosed more often.²²

Fig. 5 Year-by-year trends of open and endoscopic CTR with subsequent CRPS diagnosis, Medicare data. CRPS, complex regional pain syndrome; CTR, carpal tunnel release.

Overall, CRPS development after CTR is extremely uncommon. The privately insured population demonstrated 0.3% incidence following both surgical methods. Medicare patients demonstrated 0.1% incidence. In total, of the more than 700,000 patients that underwent CTR, only 1,300 cases of postoperative CRPS of the upper limb were reported, well below the current rates found in the literature (2–5%, $p < 0.05$). Previous investigations gathered data through longitudinal studies and chart reviews of patients who had undergone CTR.^{12,23,24} The discrepancy between our observed rate and the rate reported in the literature may be due to inconsistency in coding, publication bias from reports from select institutions, or differences in diagnosis methods.²⁵ CRPS is poorly understood and the symptoms are ill-defined, making it difficult for physicians to make a formal diagnosis. Additionally, formal diagnostic testing often requires use of specialized instruments, such as algometers, dolorimeters, and application of computer-assisted stimuli.^{1,4} Such technology is not readily available in most providers' offices and subtle abnormalities may be missed. Lack of outcome or functional scoring instruments validated for CRPS makes this disease further difficult to characterize.²⁶

Between endoscopic and open procedures, the rates of CRPS development were nearly identical which is consistent with previously reported trends in the literature.^{12–15} This establishes that the choice between an open or endoscopic technique for carpal tunnel release should not be made over concern of CRPS. Differences between the two techniques primarily lie in their different functional outcomes, recovery rates, and cost.^{15,23,27}

Within the privately insured population, rates of CTR have increased by approximately 200% since 2007, and CRPS following CTR has approximately doubled. The rates of the Medicare population were relatively constant. The difference between these two populations may indicate that more people under 65 (and therefore not in the Medicare group) are receiving CTR and developing CRPS in recent years. It is also readily apparent that the open technique is far more prevalent and that utilization of the endoscopic technique has only minimally increased (5% relative increase).

Despite the possible psychosomatic etiology of CRPS, we found that neither depression or anxiety correlated with

CRPS presence. We partially attribute the lack of statistical significance to lower than expected total numbers of these psychosocial disorders. Previous studies have demonstrated a predilection for CRPS in cases involving upper extremity, fractures, and motor nerve injuries.^{22,28} Nerve palsies and neuropathies of the hand and upper extremity are functionally and psychologically debilitating to patients. These injuries have been associated with depression, activity loss, and decreased quality of life, and may contribute to the evolution of sequelae, such as CRPS.²⁹ Future research is needed to better characterize preoperative comorbidities and risk factors for this disease.

There were several limitations to this study, most of which are inherent to studies using large medical databases.²⁵ We found an incidence of CRPS that was lower than what has been reported in the literature. This discrepancy could stem from inconsistencies in medical coding and diagnosis of CRPS, as previously noted. Interestingly, other studies on the prevalence of CRPS after CTR found that diagnosis are usually nondefinitive and that patients often recovered quickly—uncharacteristic of the disorder—indicating that some of the cases reported in these studies were not actually CRPS.^{13,14}

CRPS is diagnosed at extremely low rates after CTR in the U.S. National gender and age trends for this condition follow similar trends to those observed in multiple single center studies. Further, there is little support for the hypothesis that psychosocial disorders like depression and anxiety increase a patient's likelihood of developing CRPS after either endoscopic or open CTR. Nonetheless, because of the rapidly increasing prevalence of endoscopic and open CTR and the poorly understood pathology of CRPS, future research on preventing the syndrome is needed.

Ethical Approval

All procedures followed were in accordance with the ethical standards of the responsible committee on human experimentation (institutional and national) and with the Helsinki Declaration of 1975, as revised in 2008.¹¹ Informed consent was obtained from all patients for being included in the study.

Funding

None.

Conflict of Interest

Author J.B. was supported by the Department of Veterans Affairs (VA) Office of Academic Affiliations Advanced Fellowship in Health Services Research and Development (HSR&D). None of the other authors have received funding or financial support for this project nor have any potential sources of conflict of interest.

References

- Birklein F, O'Neill D, Schlereth T. Complex regional pain syndrome: an optimistic perspective. *Neurology* 2015;84(01):89–96
- Jänig W, Baron R. Complex regional pain syndrome is a disease of the central nervous system. *Clin Auton Res* 2002;12(03):150–164
- Maihöfner C. [Complex regional pain syndrome: a current review]. *Schmerz* 2014;28(03):319–336
- Bruehl S. Complex regional pain syndrome. *BMJ* 2015;351:h2730
- Li Z, Smith BP, Smith TL, Koman LA. Diagnosis and management of complex regional pain syndrome complicating upper extremity recovery. *J Hand Ther* 2005;18(02):270–276
- Li Z, Smith BP, Tuohy C, Smith TL, Andrew Koman L. Complex regional pain syndrome after hand surgery. *Hand Clin* 2010;26(02):281–289
- Roh YH, Lee BK, Noh JH, et al. Factors associated with complex regional pain syndrome type I in patients with surgically treated distal radius fracture. *Arch Orthop Trauma Surg* 2014;134(12):1775–1781
- Zollinger PE, Kreis RW, van der Meulen HG, van der Elst M, Breederveld RS, Tuinebreijer WE. No higher risk of CRPS after external fixation of distal radial fractures - subgroup analysis under randomised vitamin C prophylaxis. *Open Orthop J* 2010;4:71–75
- Flegal KM, Carroll MD, Kit BK, Ogden CL. Prevalence of obesity and trends in the distribution of body mass index among US adults, 1999–2010. *JAMA* 2012;307(05):491–497
- Fajardo M, Kim SH, Szabo RM. Incidence of carpal tunnel release: trends and implications within the United States ambulatory care setting. *J Hand Surg Am* 2012;37(08):1599–1605
- Buller M, Schulz S, Kasdan M, Wilhelmi BJ. The incidence of complex regional pain syndrome in simultaneous surgical treatment of carpal tunnel syndrome and dupuytren contracture. *Hand (N Y)* 2017;13(04):391–394
- da Costa VV, de Oliveira SB, Fernandes MdoC, Saraiva RÂ. Incidence of regional pain syndrome after carpal tunnel release. Is there a correlation with the anesthetic technique? *Rev Bras Anestesiol* 2011;61(04):425–433
- Chen L, Duan X, Huang X, Lv J, Peng K, Xiang Z. Effectiveness and safety of endoscopic versus open carpal tunnel decompression. *Arch Orthop Trauma Surg* 2014;134(04):585–593
- Sayegh ET, Strauch RJ. Open versus endoscopic carpal tunnel release: a meta-analysis of randomized controlled trials. *Clin Orthop Relat Res* 2015;473(03):1120–1132
- Kohanzadeh S, Herrera FA, Dobke M. Outcomes of open and endoscopic carpal tunnel release: a meta-analysis. *Hand (N Y)* 2012;7(03):247–251
- Barad MJ, Ueno T, Younger J, Chatterjee N, Mackey S. Complex regional pain syndrome is associated with structural abnormalities in pain-related regions of the human brain. *J Pain* 2014;15(02):197–203
- Lee D-H, Lee K-J, Cho KIK, et al. Brain alterations and neurocognitive dysfunction in patients with complex regional pain syndrome. *J Pain* 2015;16(06):580–586
- Pons T, Shipton EA, Williman J, Mulder RT. Potential risk factors for the onset of complex regional pain syndrome type 1: a systematic literature review. *Anesthesiol Res Pract* 2015;2015:956539
- Rewhorn MJ, Leung AH, Gillespie A, Moir JS, Miller R. Incidence of complex regional pain syndrome after foot and ankle surgery. *J Foot Ankle Surg* 2014;53(03):256–258
- Harris EJ, Schimka KE, Carlson RM. Complex regional pain syndrome of the pediatric lower extremity: a retrospective review. *J Am Podiatr Med Assoc* 2012;102(02):99–104
- Harris J, Fallat L, Schwartz S. Characteristic trends of lower-extremity complex regional pain syndrome. *J Foot Ankle Surg* 2004;43(05):296–301
- de Mos M, de Bruijn AGJ, Huygen FJPM, Dieleman JP, Stricker BHC, Sturkenboom MCJM. The incidence of complex regional pain syndrome: a population-based study. *Pain* 2007;129(1-2):12–20
- Cagle PJ Jr., Reams M, Agel J, Bohn D. An outcomes protocol for carpal tunnel release: a comparison of outcomes in patients with and without medical comorbidities. *J Hand Surg Am* 2014;39(11):2175–2180

- 24 Thomsen NOB, Cederlund RI, Andersson GS, Rosén I, Björk J, Dahlin LB. Carpal tunnel release in patients with diabetes: a 5-year follow-up with matched controls. *J Hand Surg Am* 2014; 39(04):713–720
- 25 Pugely AJ, Martin CT, Harwood J, Ong KL, Bozic KJ, Callaghan JJ. Database and registry research in orthopaedic surgery: part i: claims-based data. *J Bone Joint Surg Am* 2015;97(15): 1278–1287
- 26 Field J, Warwick D, Bannister GC. Features of algodystrophy ten years after Colles' fracture. *J Hand Surg [Br]* 1992;17(03):318–320
- 27 Zhang S, Vora M, Harris AHS, Baker L, Curtin C, Kamal RN. Cost-minimization analysis of open and endoscopic carpal tunnel release. *J Bone Joint Surg Am* 2016;98(23):1970–1977
- 28 Demir SE, Ozaras N, Karamehmetoğlu SS, Karacan I, Aytekin E. Risk factors for complex regional pain syndrome in patients with traumatic extremity injury. *Ulus Travma Acil Cerrahi Derg* 2010; 16(02):144–148
- 29 Bailey R, Kaskutas V, Fox I, Baum CM, Mackinnon SE. Effect of upper extremity nerve damage on activity participation, pain, depression, and quality of life. *J Hand Surg Am* 2009;34(09):1682–1688