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Original Research

Incidence and Treatment of Carpal Tunnel Syndrome Following Distal Radius Fractures: A TriNetX Analysis of 39,603 Patients

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A R T I C L E I N F O

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Purpose: Distal radius fractures (DRFs) are among the most common fractures and occur among all age groups. Carpal tunnel syndrome (CTS) is a known sequela of DRFs, but its incidence is poorly understood. This study was undertaken to determine the incidence of CTS following a DRF, with the hypothesis being that CTS occurs more commonly after nonsurgical treatment of a DRF.
Methods: The TriNetX US Collaborative Network was queried for all patients diagnosed with DRFs from January 2016 to December 2022. Cohorts were defined by inclusion and exclusion of the procedure Current Procedural Terminology codes into surgical and nonsurgical groups and subsequent ICD-10 diagnosis codes of CTS. Statistical analysis was performed to determine differences in management across the study period.
Results: A total of 39,603 patients met inclusion with a diagnosis of a DRF. The incidence of CTS within one year of a DRF was 5.3%. Among all DRF cases, 10,279 (26%) patients underwent surgical treatment, whereas 29,324 (74%) patients underwent nonsurgical treatment. The incidence of CTS in the surgical group was 1194 (12%), whereas the incidence of CTS in the nonsurgical group was 915 (3%). Patients undergoing surgical treatment for a DRF had a 9% risk of developing CTS, whereas patients undergoing nonsurgical treatment had a 5% risk. Among all the patients having been diagnosed with CTS, 63% of those with an operatively treated DRF underwent surgical release, whereas 23% of those with a non-operatively treated DRF underwent surgical release for CTS.
Conclusions: Patients having undergone surgical treatment for DRF had a four times higher rate of developing CTS, compared with those having undergone nonsurgical treatment. Among patients who underwent surgical treatment of a DRF with the subsequent development of CTS, there was a nearly three times higher rate of surgical release of CTS.
Type of study/level of evidence: Prognostic III.

Distal radius fractures (DRFs) account for 18% of fractures in patients aged 65 years and older, placing them among the most treated fractures in the United States.[1] As the aging population continues to grow, these numbers are anticipated to escalate further.[1,2] Historically, DRFs have been generally treated non-operatively. However, with improved fixation strategies, particularly with the advent of volar locking plates in the early 2000s, there has been an increased trend toward surgical treatment for DRFs.[2−5] Irrespective of treatment strategy, the development of carpal tunnel syndrome (CTS) is a known complication of DRF, with the incidence ranging from 0% to 20% with nonsurgical management and 0% to 14% with volar plating.[6] Theories on why CTS occurs commonly after DRFs include aggravation of asymptomatic CTS, direct trauma to the median nerve in the carpal tunnel, increased tenosynovitis of the tendons in the carpal tunnel, or altered anatomy of the carpal tunnel. Regardless, the current incidence of CTS following DRFs is not well established and how the incidence varies based on treatment strategy is poorly understood.

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Cohort	Patients in Cohort	Patients with Outcome	Risk
	Cohort Statistics		
1 DRF Su Tx	10,225	911	8.91%
2 DRF Non-Su Tx	10,225	482	4.714%

Risk Difference				Risk Ratio		Odds Ratio	
Risk Difference	95% CI	z	p	Risk Ratio	95% CI	Odds Ratio	95% CI
4.196%	(3.507%, 4.884%)	11.907	< 0.0001	1.89	(1.698,2.103)	1.977	(1.764,2.216)

Figure 1. Measures of CTS association between surgical and nonsurgical treatments for DRFs. The defined outcome used in this association was CTS with ICD-10 codes G56.01, G56.02, G56.11, and G56.12.

The purpose of this study, using the TriNetX database—a global health research network, was to analyze the incidence of CTS following both surgical and nonsurgical management for DRFs as well as the subsequent treatment applied for CTS. This study seeks to contribute evidence in identifying optimal treatment options for DRFs. The study hypothesis was that CTS occurs more commonly after nonsurgical treatment of a DRF.

Methods

TriNetX is a global research network encompassing data from more than 170 health care organizations (HCOs) and more than 400 million patients.[7] This study used the United States Collaborative Network database, which included 61 HCOs and more than 106 million patients. It contains deidentified aggregate patient information covering procedures, diagnoses, medications, vitals, genomics, and demographics. Health care organizations involved in the TriNetX network contribute health care data in deidentified, pseudo-anonymized, or limited data set formats, following local privacy regulations. These HCOs authorize the usage of these data for research purposes on the TriNetX platform. In return for providing data, HCOs incur no financial expenses and gain access to data query tools, analytics, visualization capabilities, and the necessary hardware for software execution. The deidentification process conforms to Health Insurance Portability and Accountability Act (HIPAA) Privacy Rule standards, as verified by a qualified expert, meeting the requirements of Section §164.514(b)(1), ensuring HIPAA compliance.

The TriNetX database was retrospectively queried on December 20, 2023. The TriNetX database does not involve patient-identifiable information and is subsequently exempt from Institutional Review Board review and approval.

Patient cohorts were identified using the International Classification for Disease, 10th Edition (ICD-10) diagnosis codes. All patients diagnosed with right or left DRF (ICD-10 code S52.531A and S52.532A, respectively) between January 1, 2016 and December 31, 2022 were included, resulting in a total of 39,603 patients.

Patient cohorts were subsequently defined by inclusion and exclusion of surgical fixation procedures through utilization of the Current Procedural Terminology (CPT) system codes. The surgical group consisted of 10,279 patients, included with the following CPT codes: percutaneous skeletal fixation of DRF (CPT 25606), open treatment with internal fixation of extra-articular DRF (CPT 25607), open treatment of intra-articular fracture with internal fixation of two fragments (CPT 25608), and open treatment of distal radius intra-articular fracture with internal fixation of three or more fragments (CPT 25609). The nonsurgical cohort was determined by exclusion of the aforementioned CPT codes ($n = 29{,}324$).

Both the surgical and nonsurgical patient cohorts were further analyzed with ICD-10 diagnosis codes for CTS. All patients diagnosed with right or left CTS (ICD-10 code G56.01 and G56.02, respectively) or with right or left lesions to median nerves (ICD-10 code G56.11 and G56.12, respectively) were included. This diagnosis of CTS must have occurred within 1 year from the DRF.

These patient cohorts were further analyzed by surgical treatment of CTS with CPT codes for the following: endoscopic carpal tunnel release (CPT 29846), open carpal tunnel release (CPT 64721), and neurolysis of median nerve (CPT 64708).

All statistical analyses were performed through the TriNetX platform. Propensity score matching was utilized to create cohorts with matched baseline characteristics. Using measures of association statistical analysis was performed to compare the risk of experiencing the outcomes between cohorts who received surgical treatment and nonsurgical treatment. The defined outcomes were CTS (Fig. 1) and CTR (Fig. 2). Z-tests were used to determine if the risk differed between cohorts. *P* values were used to determine statistical significance of incidence between cohorts. Odds ratio with 95% confidence interval (CI) were determined to assess the odds of an outcome between the cohorts. A P value $< .05$ was considered significant.[8]

Results

The study population consisted of 39,603 patients with a DRF diagnosis, between January 2016 and December 2022 from the TriNetX database. Of these patients, 26,930 (68%) were women and 11,881 (30%) were men. The average age of patients was 55 years, with the largest number of patients (45%) in the 65–90 age group. Racially, most patients, 29,141 (69%), identified as White (Table 1).

Overall, the incidence of CTS within 1 year of a DRF was 5.3% (2,109 CTS cases of a total of 39,603 DRF patients). Among the overall study population, 10,279 (26%) patients underwent surgical treatment while 29,324 (74%) patients underwent nonsurgical treatment. Between the two DRF treatment groups, 1,194 (12%) in the surgical treatment group were later diagnosed with CTS, whereas 915 (3.1%) in the nonsurgical treatment group were later diagnosed with CTS. Among the surgical group with CTS, 747 (63%) patients underwent carpal tunnel release (CTR) for CTS, whereas the nonsurgical group with CTS, 215 (23%) underwent (CTR) for CTS (Table 2).

When examining the demographics for the patients who underwent surgical treatment for DRF, there were 885 (74%) women

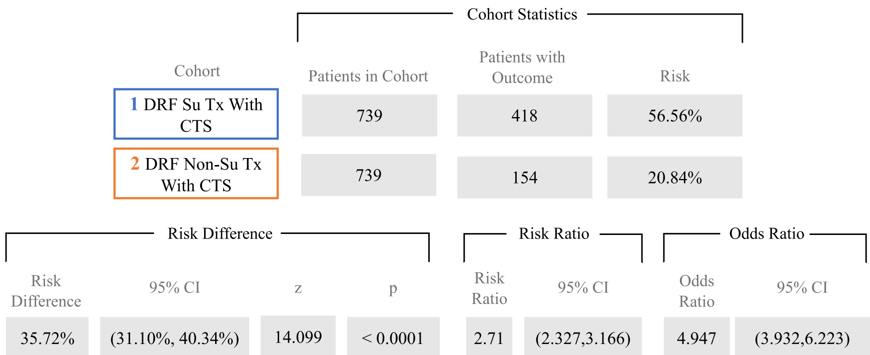

Figure 2. Measures of CTR association between surgical and nonsurgical treatments for DRFs with CTS. The defined outcome used in this association was CTR with CPT codes 29846, 64721, and 64708.

Table 1
Patient Demographics for Total DRFs*

Sex	N (%)
Females	26,790 (68%)
Males	11,821 (30%)
Age (y)	
Mean ± SD	50.6 ± 25.9
0–17	6,492 (16%)
18–39	5,872 (15%)
40–64	9,752 (25%)
65–90	18,092 (44%)
Race	
White	29,243 (74%)
Black	2,544 (6%)
Asian	1,400 (4%)
American Indian or Alaska Native	121 (0%)
Native Hawaiian or Other Pacific Islander	132 (0%)
Other race	1,439 (4%)
Unknown	4,724 (12%)

* Total number of DRFs between 2016 and 2022 with respective demographic breakdown and corresponding percentage.

Table 2
Incidence of CTS After DRFs*

	DRF Su Tx	CTS Rate	CTR Rate
N	10,279	1,194	747
Incidence	26%	12%	63%
	DRF Non-Su Tx	CTS Rate	CTR Rate
N	29,324	915	215
Incidence	74%	3%	23%

* **Top**: Incidence of su tx of DRF -> incidence of CTS following su tx of DRF -> incidence of CTR following CTS diagnosis after su tx of DRF. **Bottom**: Incidence of non-su tx of DRF -> incidence of CTS following non-su tx of DRF -> incidence of CTR following CTS diagnosis after non-su tx of DRF. *Su = surgical, Non-Su = nonsurgical, Tx = treatment.*

and 263 (22%) men diagnosed with CTS and 548 (75%) women and 158 (22%) men subsequently received surgical treatment.

When examining the demographics for the patients who underwent nonsurgical treatment for DRF, 737 (81%) women and 142 (15%) men were diagnosed with CTS and 165 (80%) women and 42 (20%) men subsequently received surgical treatment.

The incidence of CTS in the surgical treatment of DRF was 12%, whereas that in the nonsurgical treatment of DRF was 3% (*P* value < .0001) (Table 2). The DRF patients who received surgical treatment had a 9% risk of developing CTS, whereas DRF patients who received nonsurgical treatment had a 5% risk of developing CTS. In the context of risk difference, the z value was 11.9. The risk ratio was 1.89 with a CI of 1.698 and 2.103, which is statistically significant at the 5% level. The odds ratio was 1.98 with a CI of 1.764 and 2.216, which is statistically significant at the 5% level (Fig. 1).

The incidence of CTR in the surgical cohort of DRF with CTS was 63%, whereas that in the nonsurgical cohort of DRF with CTS was 23% (*P* value < .0001) (Table 2). The DRF patients with surgical treatment with CTS had a 57% risk of treating CTS surgically, whereas DRF patients who received nonsurgical treatment with CTS had a 21% risk of treating CTS surgically. In the context of risk difference, the z value was 14.1. The risk ratio was 2.71 with a CI of 2.327 and 3.166, which is statistically significant at the 5% alpha level. The odds ratio was 4.95 with a CI of 3.932 and 6.223, which is statistically significant at the 5% alpha level (Fig. 2).

Discussion

Using the TriNetX global research database, this study revealed that patients who underwent surgical treatment for DRF had a 4-fold higher rate of developing CTS compared with those who underwent nonsurgical treatment, denying the study's hypothesis that CTS occurs more commonly after nonsurgical treatment of a DRF. Within a year following DRF diagnosis, the incidence of CTS in patients treated operatively for DRF was 12%, significantly higher than the 3% incidence noted in those managed nonoperatively for DRF (*P* value < .0001). Both the risk ratio and odds ratio indicated an increased likelihood of developing CTS in the surgical treatment group, 1.89 and 1.98, respectively. In the context of risk difference, the z-value was 11.9, indicating a statistically significant deviation from the null hypothesis, and implies that the observed difference in risk between these groups is highly unlikely to be explained by random variation alone and is more likely due to the differences in treatment. This finding could be explained by the theory that those patients requiring surgical repair of their DRF may have experienced a higher energy injury with greater initial fracture displacement, lending to the greater trauma to the median nerve and increased risk for developing CTS. Moreover, the surgical intervention itself may have led to direct or indirect stress on the median nerve within the carpal tunnel increasing the rate of CTS development and the need to undergo later surgical release.

The study also found that among patients who underwent surgical treatment of a DRF with the subsequent development of CTS, there was a nearly 3-fold higher rate of surgical release of CTS. The rate of surgical treatment for CTS among patients who underwent surgical treatment for DRF was 63%, significantly higher than the 23% among those who did not undergo surgical intervention for DRF (*P* value < .0001). The risk ratio was 2.71, and odds ratio was 4.95, both indicating an increased likelihood of undergoing surgical release of CTS in the DRF surgical cohort. Additionally, the z-value was 14.1, indicating a statistically significant deviation from the null hypothesis. This finding could be explained by the theory that those patients undergoing nonsurgical treatment of a DRF may have experienced a lower energy injury with less initial fracture displacement resulting in less duress of the median nerve. The subsequent CTS may have been less symptomatic and/or the patient more committed to continued nonsurgical management.

Cooke et al performed a similar study using the PearlDiver national insurance database and found similar results to this current study. The researchers reported that patients who underwent surgical treatment for DRF had a three times higher rate of developing CTS compared with those who underwent nonsurgical treatment and had over a four times higher rate of undergoing CTR in the surgical group within 6 months following a DRF.[9] A strength of the present study lies in its extended 1-year observation window for detecting CTS diagnoses after DRFs as the time for onset of CTS after DRF can vary from a few hours to many years.[10,11] The current study also benefits from a more recent timeframe, 2016–2022, compared with the narrower scope of 2015–2017, offering more contemporary incidences. Moreover, leveraging the expansive TriNetX database, a network comprising more than 106 million patients, sets it apart from the PearlDiver database, which includes more than 22 million patients.[9]

In contrast, Lutz et al case–control study, focused on complication rates after DRFs in patients aged 65 years and older, found that the surgically treated group presented with a 6% (8/129) CTS, and in the nonsurgical treated group, the rate of CTS was 11% (14/129) in patients aged 65 years and older. Additionally, only 2% (2/129) from the surgical group and 5% (6/129) from the nonsurgical group underwent surgical release. Despite the lower CTS rate in operatively treated patients, Lutz et al[12] overall found a significantly higher rate of complications in patients treated operatively compared with the nonsurgical group.[12] Lutz et al did not address the discrepancy of findings for CTS rates in surgical and nonsurgical treatment groups but did report that the surgical treatment was not standardized. Thus, this finding could be explained by the large number of patients who were treated with external fixation, which may lead to a lower incidence of CTS versus other surgical methods such as a palmar plate fixation.

Interestingly, Ochen et al[13] meta-analysis found no difference in the overall complication rates between surgical and nonsurgical management for DRFs. This discrepancy in findings could be explained by the spectrum of complications included in the rates in the Ochen study as it included infection, nerve injury, chronic pain, complex regional pain syndrome, implant failure, and fracture healing disorders, whereas this current study isolated CTS as a complication.[13]

While there are limited studies offering comprehensive data that delineates CTS incidences after surgical and nonsurgical treatments for DRFs, there are many that address CTS incidences after either DRF treatment option. Arora et al[14] and Esenwein et al[15] analyzed the complications following palmar locking plate internal fixation of DRFs, and both reported a 3% (3/114 and 22/665, respectively, to each study) CTS incidence. Wichas et al[16] evaluated the complication rates of volar versus dorsal locking plates after DRFs and reported a less than 1% (1/285) CTS complication rate with only one patient from the palmar locking plate group with CTS. Young and Rayan[17] retrospectively evaluated function and radiographic results after nonsurgical treatment of DRFs in patients older than 60 years and reported a 12% (3/25) CTS complication rate. As exampled by these studies and in reviewing the current literature, the incidence of CTS following DRF is not well established with a widely reported range of 0.5% to 22%.[10,17–21]

This study has several limitations. As a retrospective database study, data on the severity of DRFs, mechanism of injury, and an assessment of functional outcomes are unavailable. Furthermore, there is no guarantee for standardization of CTS diagnosis as there may be varying thresholds to diagnose CTS. Moreover, the study's reliability depends on the precise coding of clinical information, which may have resulted in over- or under-identifying of CTS rates after DRF. Another limitation of the study is that the CPT codes for surgical fixation do not further delineate the different surgical options such as dorsal plating, volar plating, K-wires, etc. One study by Zhao et al[22] performed a network meta-analysis, indicating that dorsal plating fixation notably reduces the risk of CTS compared with the other fixation options. Further evidence elucidating higher CTS incidence with specific surgical techniques could offer valuable insights into selecting the most appropriate treatment option. However, this study can leverage a large cohort of DRFs treated relatively recently and presumably with modern treatment strategies yielding rates of CTS following DRF that can be of value to both treating surgeons and patients when discussing the risks and benefits of various DRF treatment options. Additionally, while there are numerous studies reporting CTS incidences after a DRF, very few delineate CTS rates in surgical treatment and nonsurgical treatment for DRF. Future studies could delve into the incidence rates of CTS following DRF, with close analysis of patient demographics, fracture characteristics, and surgical management strategies to further elucidate the risk of developing CTS after DRF.

Conclusion

Carpal tunnel syndrome is a common sequela of DRF, with an incidence of 5.3% in this study. Patients treated operatively for a DRF had a 4-fold higher incidence of developing CTS compared with those receiving nonsurgical treatment for a DRF. Among patients who underwent surgical treatment for DRF and later developed CTS, there was nearly a 3-fold increase in the rate of surgical release for CTS.

Conflicts of Interest

No benefits in any form have been received or will be received related directly to this article.

References

1. Shapiro LM, Kamal RN, Management of Distal Radius Fractures Work G, et al. Distal radius fracture clinical practice guidelines-updates and clinical implications. *J Hand Surg Am*. 2021;46(9):807–811.
2. Mauck BM, Swigler CW. Evidence-based review of distal radius fractures. *Orthop Clin North Am*. 2018;49(2):211–222.
3. Abramo A, Kopylov P, Geijer M, Tagil M. Open reduction and internal fixation compared to closed reduction and external fixation in distal radial fractures: a randomized study of 50 patients. *Acta Orthop*. 2009;80(4):478–485.
4. Karantana A, Downing ND, Forward DP, et al. Surgical treatment of distal radial fractures with a volar locking plate versus conventional percutaneous methods: a randomized controlled trial. *J Bone Joint Surg Am*. 2013;95(19):1737–1744.
5. Koenig KM, Davis GC, Grove MR, Tosteson AN, Koval KJ. Is early internal fixation preferred to cast treatment for well-reduced unstable distal radial fractures? *J Bone Joint Surg Am*. 2009;91(9):2086–2093.
6. Alter TH, Ilyas AM. Complications associated with volar locking plate fixation of distal radial fractures. *JBJS Rev*. 2018;6(10):e7.
7. TriNetX. *The Global Health Research Network*. 2024. Accessed December 20, 2023. https://trinetx.com
8. *In outcomes, what is included in Measures of Association?:* 2018, *TriNetX*. Accessed December 20, 2023. https://live.trinetx.com
9. Cooke ME, Gu A, Wessel LE, Koo A, Osei DA, Fufa DT. Incidence of carpal tunnel syndrome after distal radius fracture. *J Hand Surg Glob Online*. 2022;4(6):324–327.
10. Niver GE, Ilyas AM. Carpal tunnel syndrome after distal radius fracture. *Orthop Clin North Am*. 2012;43(4):521–527.

11. McCarroll HR Jr. Nerve injuries associated with wrist trauma. *Orthop Clin North Am*. 1984;15(2):279−287.
12. Lutz K, Yeoh KM, MacDermid JC, Symonette C, Grewal R. Complications associated with operative versus nonsurgical treatment of distal radius fractures in patients aged 65 years and older. *J Hand Surg Am*. 2014;39(7):1280−1286.
13. Ochen Y, Peek J, van der Velde D, et al. Operative vs nonoperative treatment of distal radius fractures in adults: a systematic review and meta-analysis. *JAMA Netw Open*. 2020;3(4):e203497.
14. Arora R, Lutz M, Hennerbichler A, Krappinger D, Espen D, Gabl M. Complications following internal fixation of unstable distal radius fracture with a palmar locking-plate. *J Orthop Trauma*. 2007;21(5):316−322.
15. Esenwein P, Sonderegger J, Gruenert J, Ellenrieder B, Tawfik J, Jakubietz M. Complications following palmar plate fixation of distal radius fractures: a review of 665 cases. *Arch Orthop Trauma Surg*. 2013;133(8):1155−1162.
16. Wichlas F, Haas NP, Disch A, Macho D, Tsitsilonis S. Complication rates and reduction potential of palmar versus dorsal locking plate osteosynthesis for the treatment of distal radius fractures. *J Orthop Traumatol*. 2014;15(4):259−264.
17. Young BT, Rayan GM. Outcome following nonoperative treatment of displaced distal radius fractures in low-demand patients older than 60 years. *J Hand Surg Am*. 2000;25(1):19−28.
18. Pope D, Tang P. Carpal tunnel syndrome and distal radius fractures. *Hand Clin*. 2018;34(1):27−32.
19. Heim D, Stricker U, Rohrer G. Carpal tunnel syndrome after trauma. *Swiss Surg*. 2002;8(1):15−20.
20. Rosenauer R, Pezzei C, Quadlbauer S, et al. Complications after operatively treated distal radius fractures. *Arch Orthop Trauma Surg*. 2020;140(5):665−673.
21. Seigerman D, Lutsky K, Fletcher D, et al. Complications in the management of distal radius fractures: how do we avoid them? *Curr Rev Musculoskelet Med*. 2019;12(2):204−212.
22. Zhao HL, Wang GB, Jia YQ, Zhu SC, Zhang FF, Liu HM. Comparison of risk of carpal tunnel syndrome in patients with distal radius fractures after 7 treatments. *Med Sci Monit*. 2015;21:2837−2844.