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Original Research

Prophylactic Carpal Tunnel Release During Volar Plating of Distal Radius Fractures: A Review

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Purpose: Patients who fracture their distal radius are at risk of developing carpal tunnel syndrome (CTS). Carpal tunnel syndrome occurs acutely; other patients may present with signs and symptoms of CTS weeks or months after the distal radius fracture. Because CTS may present in a delayed fashion after a distal radius fracture, some surgeons will perform carpal tunnel release (CTR) in patients who undergo open reduction and internal fixation even in those patients who do not have clinical evidence of CTS—a prophylactic CTR. In the current systematic review, we evaluated the literature regarding prophylactic CTR in the setting of surgical treatment of distal radius fractures.
Methods: We conducted our literature review based on the preferred reporting items for systematic reviews and meta-analyses guidelines. The search strategy reflected "prophylactic CTR during treatment of distal radius fractures" and was conducted in February 2024. Included studies are summarized in the Table.
Results: Six studies met the inclusion criteria. Publication dates ranged from 2001 to 2018. Five studies investigated clinical symptoms and/or electromyography: three of five studies found worsening or persistent median neuropathy, and two of five studies found improvement or no further development of symptoms in their respective patient cohorts. The sixth study found no difference in patient-reported outcomes between either approach.
Conclusions: There were no differences in wrist range of motion, postoperative grip strength, or patient-reported outcomes within each of the study cohorts. Based on the findings from the studies included in this review, we do not believe that there is sufficient evidence supporting prophylactic CTR in the setting of surgical treatment of distal radius fractures.
Type of study/level of evidence: Therapeutic 2a.

Distal radius fractures are the most commonly encountered fracture in the emergency department, accounting for 3.6 per 1,000 trauma-related emergency department visits.[1,2] Median neuropathy following distal radius fractures was described as early as 1933.[3] The incidence of carpal tunnel syndrome (CTS) following distal radius fractures varies within the literature—with most studies reporting around a 4% to 5% incidence of CTS in both operatively and nonoperatively treated distal radius fractures.[4–7]

In a cohort of 23,733 patients, Cooke et al[4] found that patients who underwent surgical treatment had a higher incidence of CTS requiring carpal tunnel release (CTR). In their cohort, 6.3% (n = 1,198) of patients treated nonoperatively developed CTS, compared with 19.8% (n = 981) in patients who underwent surgical treatment of their distal radius fracture.[4] Postulated mechanisms of median neuropathy vary but are thought to be related to changes in carpal tunnel anatomy following injury.[5] Thus, it is conceivable that patients undergoing surgical treatment for distal radius fractures have a higher amount of energy transmitted to the carpal tunnel, potentially leading to a higher clinically detectable incidence of CTS.

A subset of patients may initially have a delayed diagnosis of CTS if they have sustained polytraumatic injuries, have had a head injury, or have been intubated. In these scenarios, patients may not be able to report symptoms of CTS. In addition, patients undergoing regional anesthesia may exhibit motor or sensory deficits as a result

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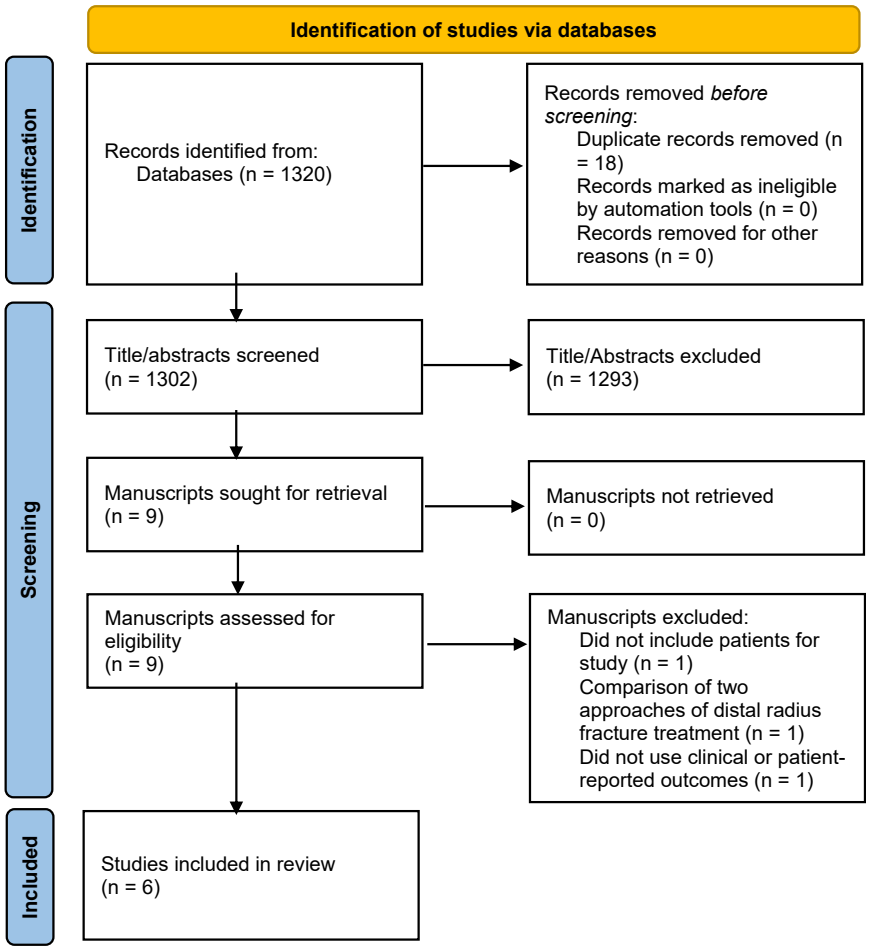

Figure. Preferred reporting items for systematic reviews and meta-analyses diagram of study selection.

of peripheral nerve blockade. Thus, symptoms of CTS may be masked during the acute period and can be diagnosed on a delayed basis.

Prior studies have explored the possibility of performing prophylactic CTR during surgical fixation of distal radius fractures for the prevention and potential treatment of median neuropathy at the wrist.[8–11] No clear consensus for indications of prophylactic CTR nor outcomes of this procedure exist. In the current review, we evaluate the literature regarding prophylactic CTR in the setting of surgical treatment of distal radius fractures. We discussed potential mechanisms of the development of CTS, risk factors, and outcomes associated with prophylactic CTR.

Methods

Study selection

We conducted our literature review based on the preferred reporting items for systematic reviews and meta-analyses guidelines (the Figure).[1] The search strategy reflected "prophylactic CTR during treatment of distal radius fractures" and was conducted in February 2024. PubMed, Scopus, CINAHL, The Cochrane Library, and clinicaltrials.gov were queried by all authors in the study. References of included studies were also reviewed for other sources that could potentially be added to the initial search. Abstracts were reviewed by all authors, after which the full text was evaluated for inclusion by the senior author (S.H.K.).

Inclusion criteria for the present study were the following: written in the English language, clinical studies investigating prophylactic CTR in the surgical treatment of distal radius fractures, standardized outcome measures, and level of evidence IV or higher. Studies that were basic science or biomechanical, compared two various approaches for distal radius fracture treatment, or did not use clinical or patient-reported outcomes were excluded. Studies included are summarized in the Table.

Results

Mechanisms of development of CTS associated with distal radius fractures

Carpal tunnel syndrome following a distal radius fracture can occur in three postinjury periods, which include acute, transient, and delayed. For patients with acute CTS, CTR is indicated in hopes of avoiding permanent injury to the median nerve. Those with transient symptoms may demonstrate resolution of CTS following treatment of the distal radius fracture. Delayed symptoms may be a result of numerous causes, including compression by fracture fragments, splint placement in the Cotton-Loder position, swelling of the carpal tunnel contents, fracture hematoma, callus formation, and edema related to manipulation of fracture fragments and soft tissues.[12] In patients with delayed symptoms, the above causes should be explored and addressed, including the potential need for CTR. Of note, CTR for median neuropathy is one of the most

Table
Summary of Findings Discussed in Prior Studies Pertaining to Prophylactic CTR in the Setting of Distal Radius Fracture Fixation

Author	Intervention/Approach	Sample Size (patients)	Results/Conclusions
Odumala et al[8]	Distal extension of the traditional volar approach of Henry	69, 24 undergoing prophylactic CTR	Seventeen patients developed postoperative median neuropathy: nine who underwent prophylactic CTR and eight who did not. Patients undergoing prophylactic CTR had twice the odds of developing postoperative median nerve dysfunction (OR = 2.7; 95% CI: 0.94–4.76).
Lattmann et al[20]	In the prophylactic CTR group, longitudinal midline incision was used; distal aspect of the volar approach of Henry used isolated patients with distal radius fractures not undergoing prophylactic median nerve decompression	174, 83 undergoing prophylactic CTR	At 1-y after surgery, persistent median neuropathy was observed in four patients in the prophylactic CTR group, compared with none in the isolated distal radius fracture fixation group. No differences in grip strength, range of motion, and patient-rated wrist evaluation at 1 y. Thus, prophylactic CTR was recommended to be abandoned because of persistent median neuropathy.
Gwathmey et al[9]	"Hybrid" single-incision flexor carpi radialis approach and prophylactic CTR	68	Delayed median neuropathy found in two patients at 2 mo and 39 mo, respectively. No further interventions were performed. Distal radius fracture fixation and prophylactic CTR can safely be performed through the described single-incision approach.
Medici et al[17]	Distal extension of the traditional volar approach of Henry	35, 16 undergoing prophylactic CTR	VAS scores were 0.8 (range: 0–3) in the prophylactic CTR group compared with 1.2 (range: 0–3) in patients undergoing isolated distal radius fracture fixation. MWS were 98.7 (range: 95–100) in the prophylactic CTR group versus 97.6 (range: 95–100) in the group not having this procedure. At 6 months after surgery, 31.58% of patients had median neuropathy on EMG in the patients undergoing isolated distal radius fracture fixation compared with no patients in the prophylactic CTR group. Routine CTR during distal radius fracture fixation may reduce postoperative median nerve dysfunction; however, there was no difference in the groups regarding patient-reported outcomes.
Al-Amin et al[11]	Various approaches among 31 included studies	2,011, 172 undergoing prophylactic CTR	The pooled rate for CTS in the patients undergoing prophylactic CTR was 28.1% (95% CI: 11.8% to 48.2%) versus 4.4% (95% CI: 3.1% to 6.0%) in patients who do not undergo this procedure. CTR has minimal prophylactic value in patients undergoing distal radius fracture fixation.
Dalton et al[10]	Various approaches for distal radius fracture fixation, and open volar approach for CTR	112, 36 undergoing prophylactic CTR	No statistically significant difference in PROMIS physical function scores and disabilities of the arm, shoulder, and hand wrist scores at final follow-up. No statistical differences in return to the operating room between groups for treatment of median nerve symptoms. Prophylactic CTR was not associated with improved patient-reported outcomes in patients undergoing surgical fixation of distal radius fractures.

VAS, visual analogue scores.

common reasons for unplanned return to the operating room following surgical treatment of distal radius fractures.[13]

Patient and injury risk factors for CTS with distal radius fractures

Numerous risk factors for median neuropathy following distal radius fractures have been reported in the literature. Dyer et al[5] found that in a cohort of 50 patients, fracture translation of 35% or more was predictive of acute CTS following distal radius fractures, including both volar and dorsal translation. Fracture type has also been found to increase the risk of acute CTS. In a retrospective review of 1,189 patients, Leow et al[14] found that patients with AO/OTA (AO and Orthopaedic Trauma Association) type C distal radius fractures had a significantly increased rate of CTS (respective incidences being type A: 3.4%, type B: 1.8%, and type C: 8.3%, $P = .001$). Rothman et al[6] also found similar results, demonstrating that intra-articular fractures had a significantly higher rate of CTS (respective incidence between 2.9% in extra-articular fractures versus 3.7% in intra-articular fractures with two fragments and 6.2% in three or more fragments, $P = .001$). This is likely because of increased energy transmitted to the carpal tunnel in these more severe injuries. In open fractures, Kim et al[15] identified four factors predictive of median neuropathy: male sex, type III open fractures, AO/OTA fracture type C, and use of external fixation. The probability of subsequent CTR increases with each of these factors, with a probability of 80% with three of these factors present. As alluded to above, type III open fractures, AO/OTA type C fractures, and use of external fixation may be a result of a higher energy injury and thus increased risk of CTS.

Patient factors have also been reported to play a role in the development of CTS. Rothman et al[6] found that age greater than 70 years (odds ratio [OR]: 0.72 [0.56, 0.94], $P = .016$) and male sex (OR: 0.82 [0.68, 0.99], $P = .035$) were predictive of CTR in the setting of distal radius fractures. Shah et al[7] found that patients who sustained polytraumatic injuries were also likely to have concomitant CTS, in addition to male sex and age younger than 50 years.

"Prophylactic" CTR during volar plating of distal radius fractures: what is the current evidence?

Median neuropathy following distal radius fractures can result from nerve contusion, compression from fracture fragments, hematoma, or edema of the carpal tunnel.[5] In hopes of addressing potential postoperative median nerve dysfunction following

fixation of distal radius fractures, some surgeons have proposed a prophylactic CTR during the index procedure in patients without acute CTS. The indications and outcomes of doing so have not been well described in the literature.

All studies included in this systematic review are summarized in the Table. One of the earliest reports investigating the possibility of prophylactic CTR was described by Odumala et al[8] in 2001. In a retrospective cohort of 69 patients with distal radius fractures, 24 underwent prophylactic CTR during fracture fixation while 45 did not. Of the 17 patients that subsequently developed median neuropathy, nine had undergone prophylactic CTR and eight did not.[8] Interestingly, patients who underwent prophylactic CTR had over twice the odds of developing postoperative median nerve dysfunction (OR = 2.7; 95% confidence interval [CI]: 0.94–4.76).[8] Thus, the authors concluded that the adjunctive prophylactic CTR did not seem to prevent postoperative CTS and instead may potentially increase the chances of median nerve dysfunction. One potential cause of postoperative CTR was proposed to be related to the implant used. However, in a cohort of 152 patients, Obert et al[16] did not find any differences between plate generation and rate of postoperative CTS.

Regarding surgical approach, Gwathmey et al[9] initially described a "hybrid" flexor carpi radialis (FCR) approach for distal radius fracture fixation, which includes a prophylactic CTR within a single incision. When performing this approach, the authors describe mobilizing the flexor carpi radialis tendon radially, exposing the proximal aspect of the transverse carpal ligament (TCL), and dividing the TCL.[9] The flexor pollicis longus tendon is then retracted radially, and the deep limb of the TCL is subsequently carefully divided. Reflecting the contents of the carpal tunnel ulnarly then allows for access to the fracture site for reduction and plating. In a cohort of 68 patients, Gwathmey Jr. and colleagues found symptoms of delayed median neuropathy in two cases at 2 months and 39 months after surgery, respectively. These symptoms were observed without further interventions performed.

In a systematic review of 31 articles, Al-Amin et al[11] found that the pooled rate of CTS in patients undergoing prophylactic CTR was higher after surgery than in patients who did not have this procedure during surgical treatment of distal radius fractures (28.1% [95% CI: 11.8% to 48.2%] vs 4.4% [95% CI: 3.1% to 6.0%], respectively).[11] Ironically, the prophylactic CTR adjunctive procedure appeared to offer minimal value in preventing postoperative CTS. One possible explanation for these findings includes a variety of approaches being used in the studies, ranging from the distal Henry, volar Henry, modified Henry, and hybrid FCR.[11] Differences in implants, diagnostic criteria for CTS, variability in follow-up (2 weeks to 45 months), and indications for CTR (ie, more severe injuries, longer tourniquet time, etc.) could also account for the increased rate of CTS in the patients who underwent prophylactic CTR. In addition, patient-reported outcomes were not clearly defined. Since a pooled analysis of these data were conducted as opposed to a meta-analysis, *P* values and odds ratios were not reported.

Medici et al[17] performed a case-control study of 35 patients, investigating visual analog scale pain scores, Mayo Wrist Score (MWS), and electromyography (EMG) at 3- and 6-month intervals following distal radius fracture fixation with and without CTR. Patients with AO/OTA type C2 fractures were included. The decision to perform CTR at the time of distal radius fracture fixation was at the discretion of the surgeon. At the 12-month follow-up, there were no statistically significant ($P > .5$) differences in visual analog scale scores or MWS between groups.[17] On EMG studies performed at 6 months after surgery, no patients in the prophylactic CTR group had median neuropathy, compared with six patients (31.6%) in the group treated without prophylactic CTR.[17] This rate of median neuropathy would be expected, as AO/OTA type C2 fractures generally result from a higher amount of energy. Of note, the patients with positive EMG findings for median neuropathy at the carpal tunnel had clinical symptoms of CTS.[17] However, it is unclear whether patients with CTS underwent subsequent CTR.

More recently, Dalton et al[10] investigated patient-reported outcomes following prophylactic CTR. Disabilities of the arm, shoulder, and hand (QuickDASH) and patient-reported outcomes measurement information system (PROMIS) physical health scores were collected in a cohort of 112 patients at the final follow-up—36 patients who had undergone concurrent CTR for acute CTS, and 76 patients who had undergone prophylactic CTR during distal radius fracture fixation.[10] Mean final follow-up was 8.9 months for the former group, and 7.8 months for the latter ($P = .7$). At the final follow-up, there were no statistically significant differences between disabilities of the arm, shoulder, and hand scores and PROMIS physical health scores in these two groups.[10] The findings support the notion that in terms of patient-reported outcomes, CTR should be performed in patients who have clinical symptoms.

Discussion

Carpal tunnel syndrome from distal radius fractures is thought to be due to changes in carpal tunnel anatomy.[5] Outlined factors that predispose patients to CTS include more complex distal radius fracture morphology and patient factors such as male sex and history of diabetes mellitus.[6,14,18] In the current literature review, we aim to outline the complex interplay of distal radius fractures and CTS and explore the potential role of performing a prophylactic CTR during distal radius fracture fixation. Six studies were included, summarized in the Table. Three of five studies found worsening or persistent median neuropathy, and two of five studies found improvement or no further development of symptoms in their respective patient cohorts.

Taken together, the studies included in our literature review suggest that the role of prophylactic CTR in patients undergoing distal radius fracture fixation remains limited. In terms of postoperative clinical symptoms of CTS, the findings described by Odumala et al[8] and Al-Amin et al[11] suggest that even when prophylactic CTR is performed, patients may still experience symptoms of CTS in a delayed fashion. If patients continue to have symptoms following prophylactic CTR, perhaps this procedure has little "prophylactic" value in all fracture types. For more complex fracture patterns, Medici et al[17] suggest that patients may actually benefit from this procedure—consistent with improved EMG findings at 6 months after surgery.[9] Thus, this procedure may have some value in patients with more severe fracture patterns. When considering patient-reported outcomes, however, the cohorts studied by Medici et al[17] and Dalton et al[10] suggest that there are no differences in patient-reported outcome measures (ie, MWS, disabilities of the arm, shoulder, and hand, and PROMIS) between patients who do and do not receive prophylactic CTR. The increased morbidity and surgical risk of the additional procedure may not be of value when considering the perspective of patient-reported outcome measures.

Based on the findings from the studies above, we do not believe that there is sufficient evidence supporting prophylactic CTR in the setting of surgical treatment of distal radius fractures. It remains unclear whether this adjunctive procedure is beneficial in the prevention of delayed CTS following surgical fixation of distal radius fractures. From an anatomical standpoint, measured carpal tunnel pressures normalize following treatment of the distal radius fracture, thus providing further evidence against prophylactic CTR.[19] Moreover, from the perspective of patient-reported outcomes, there appear to be no differences even with the implementation of the adjunctive procedure.

Of note, the surgical approach used in prophylactic CTR may also account for differences in postoperative outcomes. In the approach described by Gwathmey et al,[9] the median nerve was not manipulated. This could explain the low rate of complications with prophylactic CTR reported in this study. On the other hand, the described approach by Odumala et al[8] involves distal extension of the traditional volar Henry approach. Less favorable outcomes of prophylactic CTR in their cohort could be related to increased morbidity of the distal extension into the palm. Lattmann et al[20] also described a similar approach in a prophylactic CTR, finding an increased incidence of postoperative median dysfunction in patients with the extended volar Henry approach. Suspected causes of neuropathy were related to either direct manipulation of the median nerve or from retractor placement.[20] However, the relationship between surgical approach and postoperative median neuropathy remains unclear.

Other discrepancies in the results of the studies above may also be explained by variations in indications for when prophylactic CTR is performed, fracture pattern, fixation technique, length of postoperative follow-up, and diagnostic criteria of delayed CTS. Future studies may aim to mitigate the above differences by standardizing these factors in a randomized fashion. In addition, perhaps using a prophylactic endoscopic CTR may have differences in outcomes compared with an open approach, given that our results suggest that the surgical approach seems to influence outcomes. To our knowledge, no data comparing endoscopic versus open prophylactic CTR exist in the setting of distal radius fracture fixation and may shed more light on the role of a “prophylactic” CTR in these patients.

Conflicts of Interest

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

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