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Original Research

Management of Acute Carpal Tunnel Syndrome: A Systematic Review

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Purpose: This review aims to compare recovery outcomes of conservative, early operative, and a combination of conservative and operative management for acute carpal tunnel syndrome (ACTS).
Methods: A literature search of PubMed, Scopus, and CINAHL from 1970 to 2022 was conducted using the keywords carpal tunnel syndrome and acute nerve compression. ACTS was defined as a case within 12 weeks of symptom onset. Primary data extracted included causes (traumatic or atraumatic), symptom duration (<1 day, 1–7 days, or 8–84 days), intervention (surgical, conservative, or conservative then surgical), follow-up duration, and outcome (full recovery or non-full recovery). Logistic regression analyses and χ^2 tests were performed to investigate associations among these variables.
Results: A total of 197 patients involving 127 (64.5%) traumatic and 70 (35.3%) atraumatic cases were included. Forty-seven percent of patients were managed conservatively followed by surgery, 30% conservative only, and 23% surgery only. The traumatic group was associated with better recovery than the atraumatic group. Recovery outcomes were not associated with symptom duration or follow-up time. The choice of intervention was not associated with traumatic or atraumatic etiology, nor did it affect recovery outcomes in either group.
Conclusions: Traumatic ACTS is associated with better recovery outcomes than atraumatic etiologies. Surgical intervention was not found to be associated with better outcomes than conservative management, regardless of the etiologies. Further prospective studies are warranted to compare surgical versus conservative management.
Clinical Relevance: Currently, there are no guidelines for the best management of ACTS, and it is not known if early or delayed surgical treatment is optimal. This review compiles the current evidence and identifies gaps in the literature, highlighting the need for further investigation to provide the best clinical practice.

Carpal tunnel syndrome is a well-known neuropathy resulting from median nerve compression under the transverse carpal ligament, leading to symptoms such as pain, numbness, tingling, and weakness in the median nerve distribution of the hand. Carpal tunnel syndrome can be acute or chronic, with a chronic progressive course that lasts for at least 3 months being the most common.[1–4] Although most cases can present with mild intermittent symptoms, permanent deficits can develop in severe cases if left untreated.[1,5]

Acute carpal tunnel syndrome (ACTS) is a rare form of the carpal tunnel spectrum, characterized by its rapid progressive course and high potential for permanent changes in the local structures including nerves and muscles.[6] The onset of symptoms for ACTS typically ranges from hours to days following an inciting event, with symptoms similar to the chronic form except for the acute onset and severity tending to be more debilitating. It is most commonly associated with wrist trauma and was reported to be a complication secondary to local hemorrhage and edema in 4.3% of distal radius fractures.[7] Besides traumatically induced injuries,

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atraumatic causes have also been identified including hemorrhagic disorders, rheumatologic disorders, vascular disorders, infections, and burns.[5,6,8] Regardless of the inciting events, a rapid increase in intracompartmental pressure secondary to a mass effect is thought to be the common pathway leading to ACTS. Once the pressure exceeds a certain threshold, local blood flow is compromised and ischemia with secondary nerve conduction dysfunction and endoneurial edema can develop.[8,9] Several studies have reported the prevalence of carpal tunnel syndrome in the adult population ranging from 1% to 5% depending on diagnostic guidelines with a higher prevalence associated with obesity, older age, and woman.[10,11] However, there is limited representative data on the incidence and prevalence of ACTS. Nevertheless, ACTS is an important disease given its potential to cause permanent damage to the hand.

Although surgical intervention is reported as the preferred treatment in some traumatic ACTS cases,[12] others have reported successful treatment through conservative management.[3,13] There are no established guidelines or algorithms to direct treatment approaches. Whether to first approach ACTS with conservative management remains unclear. Therefore, the objective of this review is to investigate current evidence in the literature regarding management preferences and to compare different treatment approaches and their outcomes.

Methods

Search strategy and study selection

A comprehensive literature search of PubMed, Scopus, and CINAHL was conducted in April 2022 to identify studies that reported ACTS management in the adult population (18+ years). Literature was limited to those written in English and published from 1970 to 2022. Medical Subject Heading (MeSH) terms and keywords including Carpal Tunnel Syndrome [MeSH], Acute Disease [MeSH], and adults were used to identify literature of interest. Following duplicates removal, all titles and abstracts identified by the search criteria were screened independently by two authors (Y.K. and M.G.) for relevance. Full-text review of the remaining articles for eligibility was conducted by the same two authors independently. Carpal tunnel syndrome cases were determined as acute when patients presented to a health care setting within 12 weeks after the onset of symptoms.[2–4] Articles were excluded if they met the following: were not written in English, were not in an acute setting, did not provide acute timepoint, did not discuss treatment/management, were not in the adult population, or had no outcome assessment following treatment. Articles without a publication and letters to the editor were also excluded. A consensus was reached through discussion between the above two authors in cases of disagreement. The search adhered to the Preferred Reporting Items for Systematic Review and Meta-Analyses (PRISMA) guidelines.[14]

Assessment of quality and heterogeneity

Because of the diversity of methodologies and study designs used, a conventional meta-analysis was not feasible. Therefore, to ensure consistency in the data collected from all the studies included, two authors (Y. K. and M.G.) carefully verified that all variables were reported consistently across all studies, with any differences resolved by the senior author (K.W.). To assess potential bias in the selected studies, we used the National Institutes of Health (NIH) Study Quality Assessment Tools.[15] These tools were specific to certain study designs, and in our review, we used the tools for cohort, case–control, and case series/reports. Two authors (Y. K. and M.G.) independently assessed each study and rated its quality as good, fair, or poor based on the assessment tool guidelines. Any discrepancies were resolved through discussion until a consensus was reached.

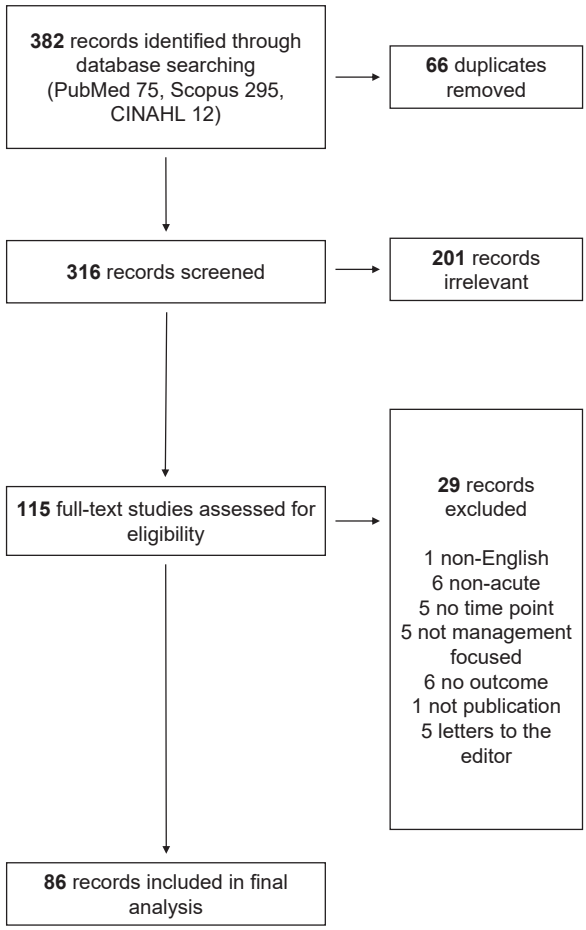

Figure. Article selection process. Diagram depicts the selection process for studies in this systematic review including databases used and exclusion criteria.

Data extraction and statistical analysis

The following data were extracted from each selected study: (1) authors and year of publication, (2) number of patients, (3) age and sex, (4) traumatic/atraumatic causes, (5) mechanism of injury, (6) duration of symptoms before presentation, (7) conservative management, (8) surgical intervention, (9) recovery outcome, and (10) follow-up time. Additionally, all cases were categorized into groups based on (1) cause (traumatic or atraumatic), (2) duration of symptoms before presentation (<1 day, 1–7 days, and 8–84 days), (3) intervention (conservative, surgical, and conservative then surgical), and (4) recovery (full recovery and non-full recovery). Traumatic causes were defined as any injury to the wrist which altered local structure/pressure originating from external forces. Atraumatic causes included any other etiologies that were not a direct result of external forces. Conservative efforts were defined as nonsurgical measures taken to relieve symptoms, most commonly including nonsteroidal anti-inflammatories, arm elevation, steroid injections, and wrist splinting. Other conservative options were targeted toward treating the underlying causes, such as medications for hyperthyroidism, vitamin B6 for deficiency, and diuretics for fluid accumulation. Surgical treatment included carpal tunnel release. Recovery outcome was assessed after intervention as either

Table 1
Traumatic and Atraumatic Causes of ACTS

Traumatic causes	Colle's fracture, burns, ulnar non-union, minor trauma on anticoagulants, injury caused by wrist motion (hyperextension, twisting), MRI-related electrical burn, carpals dislocation, snake bites, cat bites, stonefish envenomation, hemophilia A with trauma, iatrogenic, penetrating wrist trauma, blunt wrist trauma
Atraumatic causes	Infection, spontaneous hemorrhage on anticoagulation, peritendinitis calcarea, autoimmune diseases (rheumatoid arthritis), hyperthyroidism, tophaceous gout, pseudogout, post–upper respiratory tract infection, Rubella immunization, decompression illness, aneurysm of the superficial palmar arch, thrombosis persistent median artery, tumescent fluid with lipodystrophy, post-transplantation, secondary to medications, idiopathic, periarticular calcifications, atypical hand muscles, diabetic myonecrosis, myxofibrosarcoma, malignancy

full resolution or non-full resolution of the symptoms associated with carpal tunnel syndrome.

Pearson's χ^2 tests were conducted to assess interactions between (1) symptom duration and cause and (2) intervention and cause. A series of logistic regression analyses were performed to investigate and quantify the relationships between (1) recovery outcome and cause, (2) recovery outcome and symptom duration, (3) recovery outcome and intervention, (4) recovery outcome and follow-up duration, and (5) intervention and cause. Additionally, correlation analyses were conducted to assess the associations between (1) follow-up time and cause and (2) follow-up time and intervention. A $P < .05$ was considered statistical significance for all analyses.

Results

Literature search

The literature search yielded 75 articles from PubMed, 295 from Scopus, and 12 from CINAHL. Following the article screen and review, 86 articles were selected for final inclusion. Reasons for exclusion are reported in the PRISMA flowchart (Fig.). The 86 selected articles included 69 case reports, 13 case series, two retrospective, and two prospective studies.[2–4,7,13,16–95]

Methodological quality of selected articles

For quality assessment, the 86 articles were divided into three groups based on the study design categories established within the NIH Study Quality Assessment Tools: a cohort study (Supplemental Table 1, available on the *Journal*'s website at www.jhsgo.org), case–control study (Supplemental Table2, available on the Journal's website at www.jhsgo.org), and a case report/series (Supplemental Table 3 (available on the Journal's website at www.jhsgo.org). The studies were graded as follows: 1 for poor quality, 83 for fair quality, and 2 for good quality.

Characteristics of the collected cases

A total of 197 patients were extracted from collected articles in the age group of 18–91 years, including both males and females of various races. Supplemental Table 4 (available on the Journal's website at www.jhsgo.org) summarizes patient demographics, causes of ACTS, duration of symptoms, interventions, follow-up time, and recovery outcomes. Reported causes of ACTS are listed in Table 1 based on traumatic or atraumatic nature. Overall, traumatic causes accounted for approximately 65% of the studied cases. The majority of the cases had symptom duration of 1–7 days (68%), followed by 8–84 days (15%) and <1 day (17%). No significant association was found between cause and symptom duration ($P = .14$). Forty-seven percent were managed conservatively followed by surgery, 30% conservative only, and 23% surgery only. Conservative management followed by surgery was most commonly used in the traumatic group ($P < .001$) but least in the atraumatic group ($P < .0001$). Full recovery was achieved in 168 patients (85%) at follow-up 91.3 [152.1] days and 29 patients (15%) had a non-full recovery at 121.7 [220.5] days. A summary of the case breakdown based on causes (traumatic or atraumatic) is depicted in Table 2.

Recovery outcome comparison between groups

Associations between the recovery outcome and follow-up time, duration of symptoms, and intervention were investigated as shown in Table 3. In terms of causes, the atraumatic group was less likely to recover fully compared with the traumatic group (OR: 0.38, $P = .02$, 95% CI: 0.17, 0.86) (Table 2), and this association was not affected by the choice of intervention ($P = .75$). Overall, no statistically significant associations were identified between any of the variables: outcome, symptom duration, intervention, and follow-up time (Table 3). When analyzed separately based on causes (atraumatic or traumatic), no significant associations were found between outcome and symptom duration (traumatic: $P = .41$, atraumatic: $P = .31$), or outcome and intervention (traumatic: $P = .23$, atraumatic: $P = .38$) in either group (Table 4). Full recovery was found to be associated with less follow-up period in the traumatic group ($P = .04$), whereas no significant association was identified between recovery outcome and follow-up duration in the atraumatic group ($P = .76$).

Discussion

It is not known if traumatic ACTS warrants early surgical decompression or responds to conservative measures and surgeons approach this disease variably, basing it largely on their clinical interpretation and experience. Additionally, many other disease processes can mimic ACTS and further complicate the work-up. Some examples include proximal sites of compression (thoracic outlet syndrome, pronator syndrome), cervical spine diseases, systemic neurological disorders, and nerve contusion injuries.[62,96] Although ACTS can result from a wide variety of etiologies, many advocate that early recognition and prompt surgical intervention, with carpal tunnel release (CTR), are keys to preventing neurovascular damage and optimizing recovery outcomes.[37,62] Although our study did not identify a significant relationship between recovery outcome and symptom durations, we defined symptom duration as the length of time between the onset of symptoms and the patient's presentation to a health care setting. The time it took for patients to be treated after they presented to a provider was not considered. Additionally, symptom duration is subject to variations due to different methods/standards of extraction from each study. Furthermore, because our data do not contain information on treatment duration nor a direct comparison of outcomes stratified by disease severity, we do not have sufficient evidence to conclude associations between recovery outcomes and duration of symptoms. Interestingly, a study performed by Chauhan et al comparing long-term outcomes between elective CTR and acute CTR in combination with open reduction internal fixation of distal radius fractures found no differences between the two cohorts in symptom severity, functional outcomes, and Boston Carpal Tunnel Questionnaire scores.[97] However, the degree of improvement was

Table 2
Case Breakdown per Cause

Variables		Traumatic ACTS (n = 127, 64.5%)	Atraumatic ACTS (n = 70, 35.5%)	*P* Values
Symptom duration (n, % total)	<1 d	10 (15.2%)	13 (18.6%)	0.14
	1–7 d	50 (75.8%)	43 (61.4%)	
	8 – 84 d	6 (9.1%)	14 (20%)	
Intervention (n, % total)	Conservative only	33 (26%)	23 (32.9%)	**0.003***
	Surgical only	22 (17.3%)	24 (34.3%)	
	Conservative then surgical	72 (56.7%)	23 (32.9%)	
Recovery (n, % total)	Full	114 (89.8%)	54 (77.1%)	**0.02***
	Non-full	13 (10.2%)	16 (22.9%)	
Follow-up (d)		91 (45.6 – 182.5)	114 (37.7 – 205.3)	0.74

* Represents statistical significance.

Table 3
Associations between Variables

Variables	*P* Values
Outcome and symptom duration	.83
Outcome and intervention	.17
Outcome and follow-up time	.26
Follow-up time and symptom duration	.52
Follow-up time and intervention	.29

Table 4
Associations between Outcome and Symptom Duration, Intervention, and Follow-Up Time Separated by Cause

Subgroup	Variables	*P* Values
Traumatic	Outcome and symptom duration	.41
	Outcome and intervention	.23
	Outcome and follow-up time	**.04***
Atraumatic	Outcome and symptom duration	.31
	Outcome and intervention	.38
	Outcome and follow-up time	.76

* Represents statistical significance.

not determined between the two cohorts due to the lack of preoperative assessment scores. Therefore, it is possible that severity also affects clinical outcomes, although this specific determination is yet to be delineated.

Ford and Ali reported that patients recovered fully if surgical interventions were performed promptly after symptom onset.[37] Mack et al recommended approaching suspected ACTS first with conservative measures such as elevation and splinting for 2 hours.[62] If symptoms progress, carpal tunnel pressure should be measured, and CTR should be performed within 8 hours of onset if the intracarpal tunnel pressure exceeds 40 mmHg. However, although thought to be the treatment of choice by many, there is no universal consensus on the timeframe for which CTR should be performed.[98] Furthermore, it is important to note that Ford and Ali,[37] and Mack et al[62] only included ACTS resulting from traumatic fractures of the distal wrist/hand. As the characteristics of traumatic and atraumatic injuries are innately different, this raises the question of whether or not the conclusions made by the two studies apply to atraumatic ACTS. Although recommending operative decompression overall, Adamson et al indicated that conservative treatments may be considered in treating atraumatic and non–severe traumatic ACTS.[16] Our analysis indicated that although patients with traumatic etiologies received better recovery overall, the outcomes were not dependent on the choice of intervention in either traumatic or atraumatic groups.

In atraumatic cases, the precipitating medical conditions play a large role in recovery outcomes, depending on their severity, and treatments should target both managing medical conditions and providing symptomatic relief. Padua et al successfully treated bilateral ACTS with methimazole and propranolol in a patient with undiagnosed hyperthyroidism.[72] The patient experienced complete resolution of symptoms at 7 months of follow-up. Mayne et al[65] and Rahmtoola et al[78] reported treating ACTS secondary to wrist trauma in hemophilia patients with factor VIII followed by CTR, resulting in complete recovery in all cases. However, with infectious etiologies, although atraumatic, management options vary depending on the clinical course and source of infection. Sahs et al[99] mainly treated ACTS secondary to toxic shock syndrome conservatively, whereas Yoshida et al[94] and Wilheim et al[95] treated a localized infection such as tenosynovitis operatively. Other examples of conservative approaches in treating atraumatic cases included steroid injections, removal of inciting medications, rest, splinting, and hyperbaric oxygen in decompression illness.[13,33,46,58] However, there is a lack of evidence demonstrating the optimal timeframe for conservative management. Our results indicate that atraumatic ACTS is less likely to recover fully compared with traumatic etiologies. A likely explanation could be that the slower onset of symptoms that accompanies many atraumatic cases may not prompt patients to seek care immediately, which in turn results in more permanent damage to the nerve. Conversely, traumatic causes typically result in more obvious structural changes in a shorter period and may alert patients to seek care promptly. Although the difference was not statistically significant, we observed that a greater proportion of patients in the atraumatic group (20%) had symptoms lasting more than 8 days, compared with 9.1% in the traumatic cohort.

In terms of recovery time, patients have reported relief of ACTS symptoms as early as 1–5 days after intervention, regardless of intervention or whether the etiology was traumatic or atraumatic.[16,21,60,66,86] Conversely, some patients have experienced persistent symptoms for more than 1 year after intervention, independent of the underlying causes of the disease.[23,56,66,99] In our series, we found no significant differences in follow-up duration between the traumatic and atraumatic subgroups, suggesting that the more favorable outcomes observed in the traumatic cohort were because of the traumatic nature rather than the time effect. Overall, there was a trend of longer follow-up duration in those without a full recovery (121.7 [220.5] days vs 91.3 [152.1] days), and this difference became significant within the traumatic subgroup. Although follow-up duration does not necessarily correlate the recovery time, incorporating this variable into statistical analyses helps mitigate the potential confounding effects caused by the time factor.

This review is limited by the types of articles included in the final analysis. An overwhelming majority of the articles are case reports and case series, which provide lower levels of evidence compared with other types of clinical studies. Especially, there are no randomized controlled trials or comparative studies to assess and compare ACTS treatments. Additionally, although the sample

size of 197 was sufficient for logistic regression analyses with only one predictor,[100] it may not be adequate for logistic regression analyses with an interaction term. Many of the analyzed articles were published more than 10 years ago, highlighting the likely outdated information and questioning the validity of the treatment approaches reported in each study. Notably, it is possible that some patients included in the study had median neurapraxia instead of ACTS, especially in traumatic cases. Patients with median neurapraxia present similarly to ACTS patients but with a lesser degree of nerve damage, thus the management and prognosis are different than those with ACTS.[100] The determination of final recovery status was based on the reported data from each study, which may have slight variations due to differences in assessment methods and author interpretation. Finally, although all ACTS cases were considered as a single disease, the severity of each case was not considered, which could potentially have effects on recovery.

Traumatic ACTS is associated with better recovery outcomes than atraumatic causes. Prompt surgical intervention does not result in better recovery compared with a conservative approach, regardless of traumatic or atraumatic etiologies. As this study was limited by the predominance of case reports and case studies, further investigation with prospective studies is required to determine whether recovery outcomes differ between surgical and conservative management in the treatment of ACTS.

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