Surgery Article

HAND
2020, Vol. 15(1) 13–22

DOI: 10.1177/1558944718787892
journals.sagepub.com/home/HAN

Comparison of the Short-Term and Long-Term Effects of Surgery and Nonsurgical Intervention in Treating Carpal Tunnel Syndrome: A Systematic Review and Meta-Analysis

Qiyun Shi[1,2], Pavlos Bobos[1,2], Emily A. Lalone[1,2], Laura Warren[3], and Joy C. MacDermid[1,2,4]

Abstract

Background: The objective of the study is to examine the short-term and long-term efficacy of surgical treatment of carpal tunnel syndrome (CTS) compared with conservative treatment (ie, splint, steroid injection, or physical therapy). **Methods:** Two reviewers searched the Cochrane Central Register of Controlled Trials, MEDLINE, EMBASE, and PEDro up to September 2017. Quality appraisal and data extraction were performed in duplicate. Patient self-reported functional and symptom changes, as well as improvement of electrophysiological studies, were assessed as outcomes. Meta-analyses were performed in RevMan. **Results**: From 1438 studies identified after searching, 10 remained for analysis after exclusion criteria were applied. Moderate-quality evidence indicated that surgical interventions were superior to splint or steroid injection at 6 months with a weighted mean difference of 0.25 (95% confidence interval [CI], 0.07-0.44) for functional status and 0.64 (95% CI, 0.07-1.21) for symptom severity. The surgical group had better nerve conduction outcomes at 6 months (0.57 [95% CI, 0.05-0.50] ms). No significant differences were observed at 3 or 12 months. **Conclusions:** Both surgical and conservative interventions provide treatment benefits in CTS. Further studies on long-term outcome are needed.

Keywords: carpal tunnel syndrome, efficacy, surgical treatment, conservative, systematic review and meta-analysis

Introduction

Carpal tunnel syndrome (CTS) is a common entrapment neuropathy that affects 3% to 12% of adults in America.[18,25] CTS often presents with pain, numbness, tingling, and weakness in the hand and arm. Delayed treatment in CTS may worsen the symptoms and progresses to permanent sensory loss and thenar paralysis in some cases.[11,21] However, surgery can also be associated with complications. Conservative management is often used for mild cases or symptom relief while awaiting surgery. In 2016, The American Academy of Orthopedic Surgeons (AAOS) released updated clinical practice guidelines (CPG)[2] for the management of CTS and associated appropriate use criteria (AUC).[1] The CPG indicated conservative management has benefit, but that surgery has a greater treatment benefit at 6 and 12 months than splinting, nonsteroidal anti-inflammatory drugs (NSAIDs)/therapy, or single steroid injections.[2]

A 2011 systematic review concluded that both surgical and nonsurgical interventions are beneficial to patients with CTS.[24] Although preceding the publication of the AAOS CPG, this review also suggested that patients who received surgical treatment had greater improvement in symptoms severity and function at 6 and 12 months.[24] However, with emerging literature[4,7,10,15] the conclusions from systematic reviews are always subject to changing or more definitive solutions. The systematic review indicates the nature of the difference between treatment options, but meta-analysis is

[1]Western University, London, ON, Canada
[2]St. Joseph's Health Centre, London, ON, Canada
[3]University of Toronto, ON, Canada
[4]McMaster University, Hamilton, ON, Canada

Supplemental material is available in the online version of the article.

Corresponding Author:
Qiyun Shi, Health and Rehabilitation Sciences, Western University, Room 1014, Elborn College, 1201 Western Road, London, ON N6G 1H1, Canada.
Email: qshi26@uwo.ca

required to quantify can quantify the size of treatment benefits which can be critical to decision-making, particularly where there are the treatment options are associated with substantially different complications or costs. More recently, Grading of Recommendations Assessment, Development and Evaluation (GRADE) has provided a clear and informative approach to convey the findings from evidence synthesis consider both the quality of the evidence and some of the additional factors that could affect decision-making.

Nonsurgical interventions include a variety of treatment options. Since splint, steroid injection and manual therapy are the most commonly used nonsurgical interventions in treating CTS. Therefore, to reduce clinical heterogeneity in this review, we restricted our nonsurgical intervention to those 3 modalities. The purpose of this systematic review and meta-analysis was to evaluate current evidence comparing the efficacy of surgical and nonsurgical interventions (ie, splint, steroid injection, or physical therapy) for CTS for short-term (1 and 3 months) and long-term outcomes (6 and 12 months).

Materials and Methods

We conducted this systematic review and meta-analysis according to PRISMA guidelines.[22] A literature search was conducted from 1980 to September 2017 for studies addressing the effectiveness of surgical or nonsurgical interventions for CTS. The search strategy is included in Supplemental File 1. The following databases were searched: Cochrane Central Register of Controlled Trials (CENTRAL) (The Cochrane Library Issue 9, 2017), MEDLINE (1980 to September 2017), EMBASE (1980 to September 2017), PEDro (searched in September 2017). Searching of international CPG, computer searches based on keywords, and hand searching for references from previously retrieved articles were used to in addition to the main search strategy of electronic databases. Research articles were included for review if they met the following criteria: (1) studies were written in English; (2) studies were designed as a prospective controlled trial; (3) subjects/patients had a diagnosis of CTS, irrespective of the diagnostic criteria used, etiology of the syndrome, or associated pathology; and (4) comparison of a surgical with a nonsurgical intervention.

The surgical treatments included (1) standard open carpal tunnel release (OCTR); (2) endoscopic carpal tunnel release (ECTR); (3) OCTR with additional procedures such as internal neurolysis, epineurotomy, or tenosynovectomy; and (4) OCTR using any other incision techniques.

Nonsurgical treatment includes (1) wrist splints, (2) steroid injection (without the limit the number of injection), and (3) physical therapy, therapeutic exercises, or manipulations.

Research articles were excluded from review if the comparison was between 2 surgical interventions or between different nonsurgical interventions or if data on the intervention effectiveness were not provided.

The primary outcome measure was patient self-reported function and symptom improvement at 6 months of follow-up. Secondary outcomes were the patient self-reported function and symptom improvement at 1, 3, and 12 months of follow-up and the improvement of neurophysiological parameters. Institutional review board approval is not required for this study as this is a review.

Data Collection

Two study authors (PB and EL) independently performed the study selection, assessment of methodological quality and data abstraction with disagreements resolved by an independent third rater (QS). Missing data were obtained by contacting authors or estimated following Cochrane Handbook.[13] Quality assessment was assessed using the Jadad scale[16] and the Structured Effectiveness Quality Evaluation Scale (SEQES) (see Supplemental File 3).[24] Both scales were used as complementary assessments: the Jadad is brief and the SEQES provides a more comprehensive assessment, including allocation concealment. A decision was made by the reviewers that the study was high quality if the cumulative score was 3 or more on Jadad score. For SEQES scores, trial scorings less than 18 was considered low quality; those scoring between 18 and 32 were moderate quality and 33 or more were high quality.

Data Synthesis and Analysis

A number of self-administrated scales (eg, Boston, Carpal Tunnel Syndrome Assessment Questionnaire [CTSAQ]) were used to measure symptom and disability across different studies. We converted these scales to a 1 to 5 Likert scale (1 = least symptom or disability to 5 = worst symptom or disability). The Boston Questionnaire[19] is a CTS-specific tool for patients to self-report their symptom severity (11 items) and functional status (8 items). The overall score ranges from 1 to 5, with higher scores representing more severe symptoms or functional impairment. The CTSAQ is a modified version of the Boston Questionnaire, which includes 11 questions for symptom and 9 questions for function[5] with a similar scoring to the Boston Questionnaire. We converted the CTSAQ to 1 to 5 scoring so make the 2 scales comparable in the meta-analysis. For studies which used the visual analogue scale[7,20] to score symptom severity and functional status, scores were converted to the metrics used by the Boston Questionnaire as these 2 measures are highly correlated.[19]

Follow-up time was grouped into 4 categories: 1, 3, 6, and 12 months following the intervention. When the exact

time point was not matched to above categories, the time closest to the above time points was used (eg, 20-week outcomes were grouped into the 6-month category). Statistical analysis was performed using Review Manager (RevMan) version 5.3.[8] Weighted mean differences (WMDs) were calculated to compare postintervention and preintervention symptom and function scores. Based on previous studies, we considered a 0.8 points difference on the symptom scale and 0.5 points difference on the function scale as were considered as "clinically important" differences.[19] A random-effects model was used to account for heterogeneity between studies. Study results were assessed for heterogeneity using the chi-square statistic (P value < .05 considered statistically significant) and an I^2 test (I^2 >50% considered substantial heterogeneity).[13] Where possible, causes of heterogeneity for I^2 values that were greater than 50% were explored.

The GRADE criteria were considered to determine the overall quality of the evidence for each intervention and outcome.[3] The quality of evidence was downgraded a level if any of the following were present: high risk of bias (≥25% of trials, had a low Jadad or SEQES score), inconsistency of results (≥25% of the trials, had results which were not in the same direction), indirectness (≥25% of the trials, had results which were indirect comparisons of populations, interventions, comparators, or outcomes), imprecision (sample size <280), and publication bias (assessed using funnel plot analysis). The overall quality of evidence was defined as "high quality," "moderate quality," "low quality," and "very low quality."[20]

Results

Overall, a total of 10 trials with 1028 participants included in this review (Table 1, Figure 1)[4,7,9,10,12,14,15,17,20,26] (Supplemental File 1: search strategy and Supplemental File 2: PRISMA-2009-Checklist-CTS). Eight studies employed standard OCTR as the surgical intervention. Six studies compared surgery with steroid injection,[4,7,9,14,15,20] 2 compared surgery versus splint,[12,26] and 2 compared surgery versus manual therapy.[10,17] Although some patients failed conservative treatment and were reallocated to receive the surgical intervention, this number was small in the included studies. The level of evidence was presented in Table 2. The methodological features of each study are summarized in Supplemental File 3: Study Quality_SEQES and Supplemental File 4: Jade score.

Treatment Efficacy: Functional, Symptoms, and Electrophysiological Outcomes

Short-term outcome (1 and 3 months). There was limited data on functional outcomes 1-month postintervention with only one study with a low risk of bias reporting functional outcomes at this time point. The authors found nonsurgical interventions were superior to surgical intervention with a weighted mean difference of 0.80 (95% confidence interval [CI], 0.60-1.00). On the contrary, there was moderate-quality evidence indicating no statistically significant difference between surgical and nonsurgical interventions for symptom outcomes 1 month after treatment (Figure 3). For 3 months follow-up, there was low- to moderate-quality evidence of no statistically significant differences between surgical and nonsurgical interventions for either functional or symptom outcomes.

Long-term outcome (6 and 12 months). Moderate-quality evidence showed that surgical interventions were superior to nonsurgical interventions at 6 months with the weighted mean difference 0.25 (95% CI, 0.07-0.44) for functional status and 0.64 (95% CI, 0.07-1.21) for symptom severity (Figures 2 and 3). However, this effect declined at 12 months follow-up: functional status (0.22; 95% CI, –0.04-0.48) and symptom severity (0.22; 95% CI, –0.05-0.50) based on low- to moderate-quality evidence. Moderate-quality evidence showed that greater distal sensory latency improvement occurred in the surgical intervention group compared with the nonsurgical intervention group with a mean difference of 0.57 (95% CI, –0.05-0.50) ms at 6 months (Figure 4).

Discussion

The results of this study based on 10 trials with 1028 participants indicate that both surgical and conservative interventions are effective in the management of CTS. This study provides more definitive estimates of treatment effects based on meta-analysis indicating that surgical interventions have small to moderate superiority in size of treatment benefit.

Our review included studies addressing different types of conservative management, which is often multimodal. Conversely, the 2016 AAOS[1] based their search on specific clinical questions and make recommendations only about these specific questions. As the search strategy, search dates, and inclusion/exclusion criteria differed, we did not analyze exactly the same evidentiary pool as AAOS. However, there is some discordance between our findings based on the fact we both used a stringent methodology and some common studies. As wrist immobilization is a core element of conservative management, our findings are aligned with the 2016 AAOS recommendation that "Strong evidence supports that the use of immobilization (brace/splint/orthosis) should improve patient-reported outcome."[1] On the contrary, AAOS found "Strong evidence supports that surgical treatment of carpal tunnel syndrome should have a greater treatment benefit at 6 and 12 months as compared to splinting, NSAIDs/therapy, and a single steroid injection."

Table 1. Summary of Study Characteristics.

ID	Author(s)	Year	Country	Design	Sample size	Inclusion and exclusion criteria	Study quality (Jadad, SEQES scores)
1	Celik and Ilik	2015	Turkey	RCT	**100** 50 (MIS) 50 (one-dose steroid injection)	1. Moderate clinical diagnosis of CTS greater than 3 months. 2. Confirmed by electrodiagnostic studies.	0/5 28/50
2	Awan et al	2015	Pakistan	RCT	**116** 58 (MIS) 58 (one-dose steroid injection)	Moderate clinical diagnosis of CTS.	1/5 29/50
3	Fernandez-de-Las Peñas et al	2015	Spain	RCT	**120** 60 (OCTR or ECTR) 60 (manual therapy)	1. Clinical diagnosis of CTS greater than 12 months. 2. Electrodiagnostic studies were used for equivocal cases. 3. All participants are women. 4. Excluded if previous treatment with CTS release surgery or steroid injection, age >65 years, ulnar or radial nerve deficit, depression.	4/5 46/50
4	Ismatullah	2013	Pakistan	RCT	**40** 20 (OCTR) 20 (one-dose steroid injection)	1. Clinical diagnosis of CTS greater than 3 months. 2. Electrodiagnostic studies were used for equivocal cases. 4. Excluded if previous treatment with CTS release surgery or steroid injection.	1/5 25/50
5	Jarvik et al	2009	United States	RCT	**116** 57 (OCTR or ECTR) 59 (multimodality[a])	1. Clinical diagnosis of CTS greater than 2 weeks. 2. Confirmed by electrodiagnostic studies. 3. In absence of electrodiagnostic criteria, positive in night pain and flick test. 4. Excluded if previous treatment with CTS release surgery, severe thenar muscle atrophy.	3/5 41/50

(continued)

Table 1. (continued)

ID	Author(s)	Year	Country	Design	Sample size	Inclusion and exclusion criteria	Study quality (Jadad, SEQES scores)
6	Ucan et al	2006	Turkey	RCT	**57** 11 (OCTR) 23 (splinting) 23 (splinting + one-dose steroid injection)	1. Mild to moderate clinical diagnosis of CTS greater than 6 months. 2. Confirmed by electrodiagnostic studies. 3. Excluded if advanced CTS, thenar atrophy, or previous CTS treatment.	2/5 35/50
7	Ly-Pen et al	2005	Spain	RCT	**163** 80 (OCTR) 83 (one- or two-dose steroid injection)	1. Clinical diagnosis of CTS greater than 3 months. 2. Confirmed by electrodiagnostic studies. 3. Excluded if previous treatment with CTS release surgery, severe thenar muscle atrophy.	3/5 36/50
8	Hui et al	2005	Hong Kong	RCT	**50** 25 (OCTR) 25 (one-dose steroid injection)	1. Clinical diagnosis of CTS greater than 3 months but less than 1 year. 2. Confirmed by electrodiagnostic studies. 3. Excluded if severe thenar muscle atrophy, ulnar, radial neuropathy.	3/5 40/50
9	Demirci et al	2002	Turkey	Comparative cohort study	**90** 44 (OCTR) 46 (two-dose steroid injection)	1. Clinical diagnosis of CTS greater than 6 months. 2. Confirmed by electrodiagnostic studies. 3. Excluded if previous steroid injection, OCTR or distal radius fracture.	0/5 31/50
10	Gerritsen et al	2002	Netherlands	RCT	**176** 87 (OCTR) 89 (splinting)	1. Clinical diagnosis of CTS. 2. Confirmed by electrodiagnostic studies. 3. Excluded if severe thenar muscle atrophy.	3/5 42/50

Note. Total number of trial that included all arms are indicated in bold. SEQES = Structured Effectiveness Quality Evaluation Scale; RCT = randomized clinical trial; MIS = minimal invasive surgery; CTS = carpal tunnel syndrome; OCTR = standard open carpal tunnel release; ECTR = endoscopic carpal tunnel release. [a]Includes nonsteroidal anti-inflammatory drugs, hand therapy, and ultrasound.

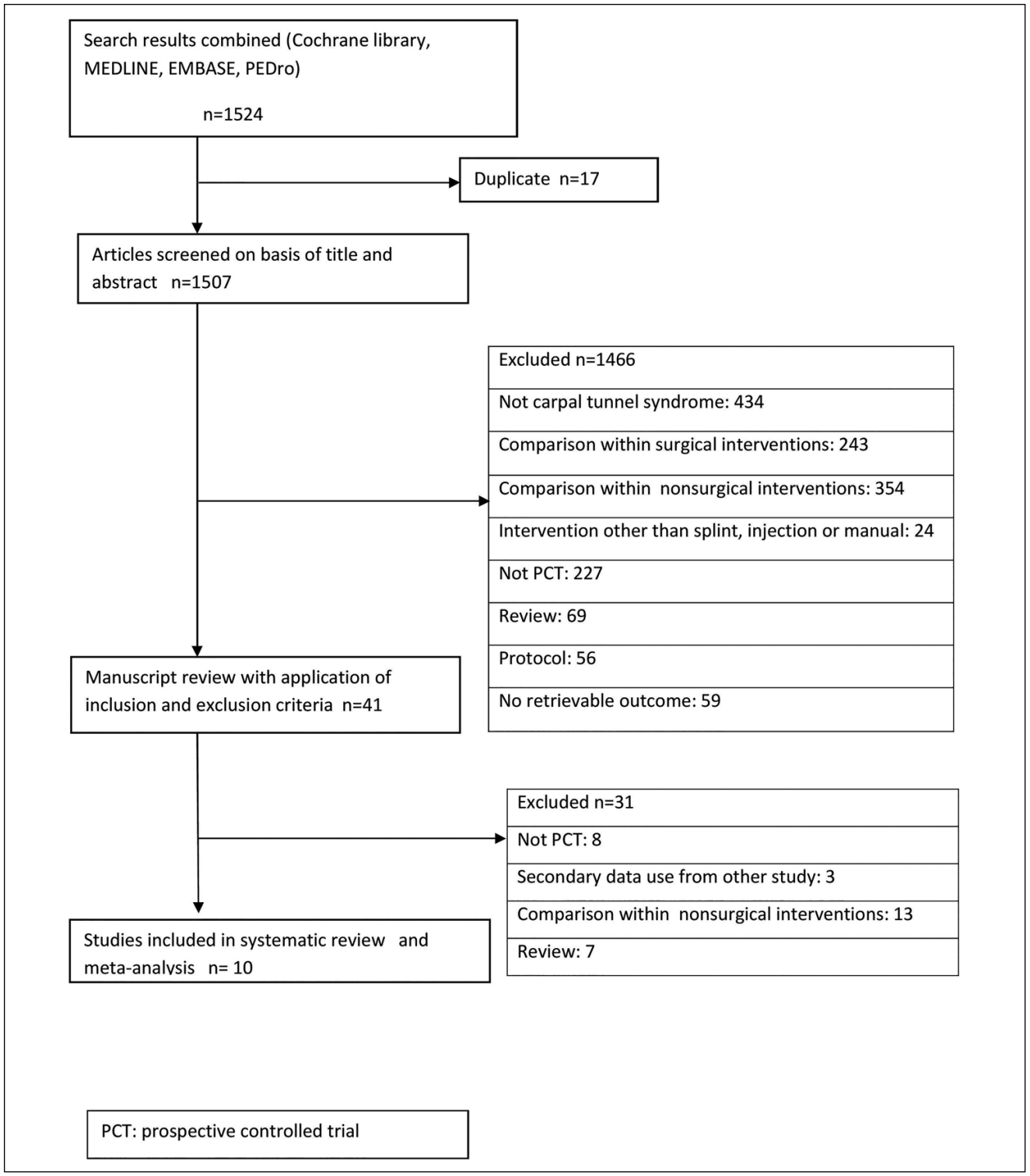

Figure 1. Schema of systematic review.

We found moderate-quality evidence that surgical interventions were superior to nonsurgical interventions at 6 months but the effects diminish at 12 months.

Differences between this systematic review and the AAOS guideline rating of the quality of evidence were also related to the process for quality rating and synthesis across

Table 2. Level of Evidence of Surgical Versus Nonsurgical Intervention for Carpal Tunnel Syndrome.

	High risk of bias	Inconsistency	Indirectness	Imprecision	Publication bias	Overall evidence
Functional changes						
1 month		NA		✓	NA	NA
3 months		✓		✓		Low
6 months					✓	Moderate
12 months				✓	✓	Low
Symptom changes						
1 month				✓		Moderate
3 months		✓				Moderate
6 months					✓	Moderate
12 months				✓		Moderate
Nerve conduction studies at 6 months-distal sensory latency, ms				✓		Moderate

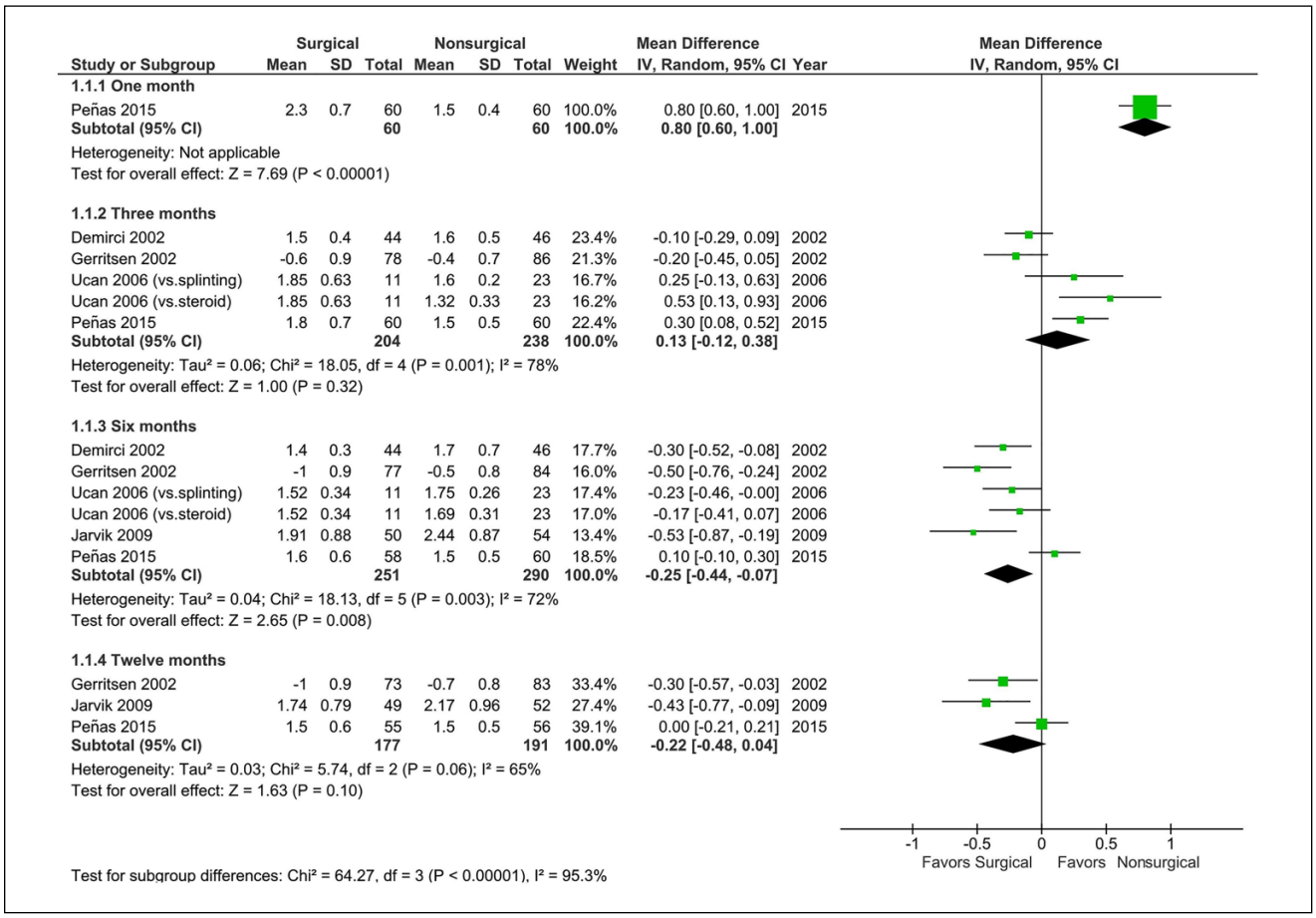

Figure 2. Patient self-reported functional severity.
Note. CI = confidence interval.

studies. Although both this systematic review and the AAOS CTS CPG adopted principles of GRADE, the implementation of these varied. Furthermore, we relied on meta-analysis to quantify overall effect sizes. Differences in quality of the evidence and the size of the treatment effect are important considerations when making recommendations, as the lower

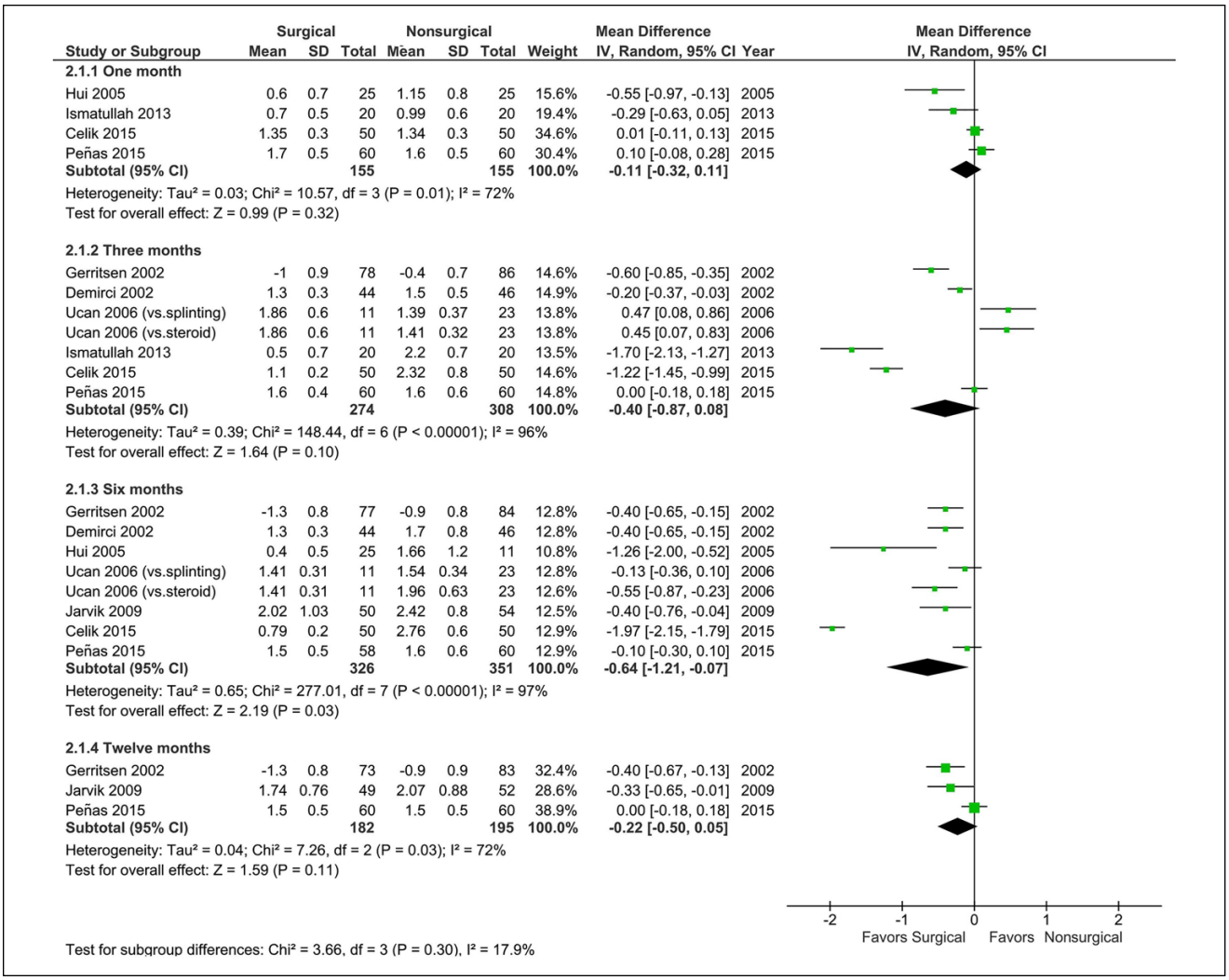

Figure 3. Patient self-reported symptom severity.
Note. CI = confidence interval.

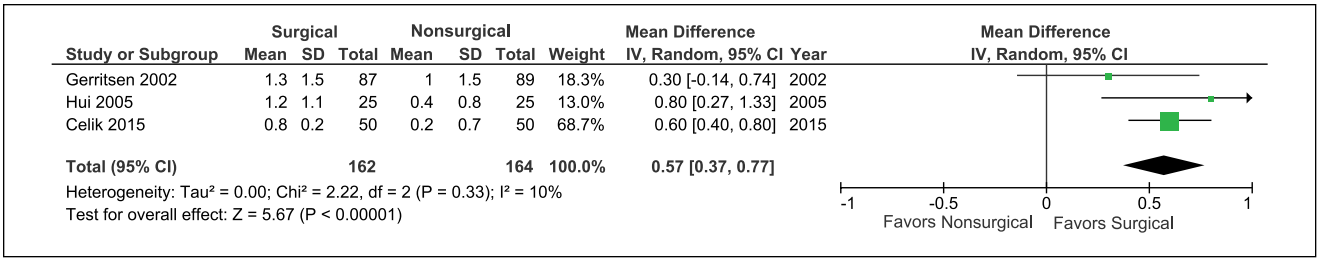

Figure 4. Distal sensory latency improvement at 6 months.

quality of evidence and smaller size of treatment effects would lead to a weaker recommendation for which intervention might be optimal. Further considerations such as patient values and preferences, recovery, and risk for complications are more important when treatment effect size differences are small. The AAOS has extended the clinical relevance of its CPG by developing CTS AUC, which provide more guidance on how clinical presentation and judgment might affect the applicability of practice guideline recommendations. This did include AUC to choose patients who will

benefit surgery over conservative management.[1] The evidence and AUC concur in supporting the common practice of a trial of conservative management prior to surgical intervention. Satisfactory outcomes may mitigate the patient's motivation for surgical intervention. Conversely, inadequate symptom relief emphasizes the need for surgical release.

We did not find strong evidence for 12-month outcomes. Patients who received surgical treatment for CTS had more function and fewer symptoms than patients who received nonsurgical treatment at 12 months postintervention, but in our meta-analysis, this difference was no longer statistically significant. This result is largely driven by the 2015 Peñas study,[10] which suggested a superior benefit to manual therapy when compared with surgery. As this is not the current first line of conservative treatment in CTS, it demonstrates the potential downfall of lumping together different types of conservative management. However, when only one randomized clinical trial (RCT) addresses a novel approach, it can be difficult to confident that approach is truly superior. A study conducted by Pensy and colleagues[23] on the efficacy of CTS surgery found that functional and symptomatic improvements occurring after 6 months were sustained for an average of 6 years of follow-up. The lower value of statistical significance from 6 months to 12 months of follow-up for functional and symptom improvement in our meta-analysis can be explained by the fact that only 3 studies included 12 months follow-up. Thus, the 12-month evaluation is imprecise and subject to change.

Surgical intervention was superior to nonsurgical intervention for treatment of CTS after 6 months for both functional status and symptom severity. However, the difference of effect size does not achieve our prior determined clinically meaningful difference of 0.5. This highlights the importance of considering both effect size and statistical significance when deciding whether one treatment should be routinely used in another treatment. Strong evidence does not warrant strong recommendations where the difference in treatment effects are small, particularly if one treatment has greater risks. This is relevant when comparing surgical with nonsurgical interventions as both risks and benefits all are typically considered to be higher for surgical interventions. Although CTS release is one of the most common and safest surgical interventions, complication rates vary from 1% to 12%.[6] However, the incidence of side effects of conservative interventions, such as steroid injection, are lower than surgery. In one study, 0.4% of patients developed cellulitis after steroid injection.[14] Therefore, conservative treatment options may provide sufficient treatment benefit for a substantial portion of the population, and have minimal risk. Therefore, due to the observed treatment benefits of conservative management, its continued role as a front-line treatment is justified. With the move toward AUC,[5] better definition of patients for whom initial conservative management may not be useful should be better defined. Selection of patients for surgery based on more severe symptoms and insufficient relief after 6 months of nonsurgical intervention is supported by these findings.

This review provides more definitive conclusions than our previous review,[26] by adding 4 additional trials and more follow-up time points for meta-analysis. Furthermore, we reduced clinical heterogeneity by focusing on the conservative treatments in common use. Other potential sources of heterogeneity include variations in how CTS is diagnosed as electrodiagnostic and clinical methods vary. Due to the small number of studies reporting outcomes at 12 months and a lack of data with longer follow-up, the conclusion that clinical improvement with surgery declined after 6 months might be questionable. Future high quality studies with longer follow-up periods are warranted to better understand the longer term trajectory of surgical outcomes. Potential differences within surgical or conservative management approaches can only be explored when an appropriate pool of RCTs is established.

Ethical Approval

Ethical approval was not required for this study.

Statement of Human and Animal Rights

This article does not contain any studies with human or animal subjects.

Statement of Informed Consent

Informed consent was obtained when necessary.

Declaration of Conflicting Interests

The author(s) declared the following potential conflicts of interest with respect to the research, authorship, and/or publication of this article: Qiyun Shi, Pavlos Bobos, Emily A. Lalone, Laura Warren have no competing interest. Joy C. MacDermid holds The James Roth Research Chair in Musculoskeletal Health and CIHR Chair: Gender, Work and Health.

Funding

The author(s) received no financial support for the research, authorship, and/or publication of this article.

ORCID iDs

P Bobos https://orcid.org/0000-0002-5098-4840
EA Lalone https://orcid.org/0000-0002-0946-2493

References

1. American Academy of Orthopaedic Surgeons. *Appropriate Use Criteria for the Management of Carpal Tunnel Syndrome*. http://www.orthoguidelines.org/go/auc/auc.cfm?auc_id=224989. Published December 9, 2016. Accessed July 2, 2018.

2. American Academy of Orthopaedic Surgeons. *Management of Carpal Tunnel Syndrome Evidence-Based Clinical Practice Guideline*. www.aaos.org/ctsguideline. Published February 29, 2016. Accessed July 2, 2018.
3. Atkins D, Eccles M, Flottorp S, et al. Systems for grading the quality of evidence and the strength of recommendations I: critical appraisal of existing approaches The GRADE Working Group. *BMC Health Serv Res*. 2004;4(1):38.
4. Awan AS, Khan A, Afridi SA, et al. Early response of local steroid injection versus mini incision technique in treatment of carpal tunnel. *J Ayub Med Coll Abbottabad*. 2015;27(1):192-196.
5. Bessette L, Sangha O, Kuntz KM, et al. Comparative responsiveness of generic versus disease-specific and weighted versus unweighted health status measures in carpal tunnel syndrome. *Med Care*. 1998;36(4):491-502.
6. Boeckstyns ME, Sørensen AI. Does endoscopic carpal tunnel release have a higher rate of complications than open carpal tunnel release? an analysis of published series. *J Hand Surg Br*. 1999;24(1):9-15.
7. Celik G, Ilik MK. Effects of two different treatment techniques on the recovery parameters of moderate carpal tunnel syndrome: a six-month follow-up study. *J Clin Neurophysiol*. 2016. doi:10.1097/WNP.0000000000000243.
8. Copenhagen: The Nordic Cochrane Centre TCC. Review Manager (RevMan) [Computer program]. Version 5.3. Copenhagen: The Nordic Cochrane Centre, The Cochrane Collaboration. 2014. http://community.cochrane.org/help/tools-and-software/revman-5.
9. Demirci S, Kutluhan S, Koyuncuoglu HR, et al. Comparison of open carpal tunnel release and local steroid treatment outcomes in idiopathic carpal tunnel syndrome. *Rheumatol Int*. 2002;22(1):33-37. doi:10.1007/s00296-002-0184-0.
10. Fernandez-de-Las Penas C, Ortega-Santiago R, de la Llave-Rincon AI, et al. Manual physical therapy versus surgery for carpal tunnel syndrome: a randomized parallel-group trial. *J Pain*. 2015;16(11):1087-1094. doi:10.1016/j.jpain.2015.07.012.
11. Ford DJ, Ali MS. Acute carpal tunnel syndrome. Complications of delayed decompression. *J Bone Joint Surg Br*. 1986;68(5):758-759.
12. Gerritsen AA, de Vet HC, Scholten RJ, et al. Splinting vs surgery in the treatment of carpal tunnel syndrome: a randomized controlled trial. *JAMA*. 2002;288(10):1245-1251.
13. Higgins JPT, Altman DG, Gotzsche PC, et al. The Cochrane Collaboration's tool for assessing risk of bias in randomised trials. *BMJ*. 2011;343:d5928. doi:10.1136/bmj.d5928.
14. Hui ACF, Wong S, Leung CH, et al. A randomized controlled trial of surgery vs steroid injection for carpal tunnel syndrome. *Neurology*. 2005;64(12):2074-2078. doi:10.1212/01.WNL.0000169017.79374.93.
15. Ullah I. Local steroid injection or carpal tunnel release for carpal tunnel syndrome—which is more effective? *J Postgrad Med Inst*. 2013;27(2):194-199.
16. Jadad AR, Moore RA, Carroll D, et al. Assessing the quality of reports of randomized clinical trials: is blinding necessary? *Control Clin Trials*. 1996;17(1):1-12. doi:10.1016/0197-2456(95)00134-4.
17. Jarvik JG, Comstock BA, Kliot M, et al. Surgery versus non-surgical therapy for carpal tunnel syndrome: a randomised parallel-group trial. *Lancet*. 2009;374(9695):1074-1081. doi:10.1016/S0140-6736(09)61517-8.
18. Leblanc KE, Cestia W. Carpal tunnel syndrome. *Am Fam Physician*. 2011;83(8):952-958.
19. Leite JC, Jerosch-Herold C, Song F. A systematic review of the psychometric properties of the Boston Carpal Tunnel Questionnaire. *BMC Musculoskelet Disord*. 2006;7:78. doi:10.1186/1471-2474-7-78.
20. Ly-Pen D, Andréu J-L, de Blas G, et al. Surgical decompression versus local steroid injection in carpal tunnel syndrome: a one-year, prospective, randomized, open, controlled clinical trial. *Arthritis Rheum*. 2005;52(2):612-619. doi:10.1002/art.20767.
21. Mack GR, McPherson SA, Lutz RB. Acute median neuropathy after wrist trauma. The role of emergent carpal tunnel release. *Clin Orthop Relat Res*. 1994(300):141-146.
22. Moher D, Liberati A, Tetzlaff J, et al. Preferred reporting items for systematic reviews and meta-analyses: *Ann Intern Med*. 2014;151(2):264-269.
23. Pensy RA, Burke FD, Bradley MJ, et al. A long-term outcome study of carpal tunnel syndrome: patients who underwent surgery vs. those who declined. *J Hand Surg Am*. 2017;35(10):32-33. doi:10.1016/S0363-5023(10)60112-8.
24. Shi Q, MacDermid JC. Is surgical intervention more effective than non-surgical treatment for carpal tunnel syndrome? a systematic review. *J Orthop Surg Res*. 2011;6:17. doi:10.1186/1749-799x-6-17.
25. Thiese MS, Gerr F, Hegmann KT, et al. Effects of varying case definition on carpal tunnel syndrome prevalence estimates in a pooled cohort. *Arch Phys Med Rehabil*. 2014;95(12):2320-2326.
26. Ucan H, Yagci I, Yilmaz L, et al. Comparison of splinting, splinting plus local steroid injection and open carpal tunnel release outcomes in idiopathic carpal tunnel syndrome. *Rheumatol Int*. 2006;27(1):45-51. doi:10.1007/s00296-006-0163-y.