CTS Associated or Caused by Other Medical Conditions

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Hand surgeons should be familiar with a variety of medical conditions associated with carpal tunnel syndrome (CTS). In some instances, the presence of an underlying medical disease may influence treatment or prognosis. For example, the progression of CTS symptoms in a patient with rheumatoid arthritis can signal increased flexor tenosynovitis and the need for more aggressive rheumatologic treatment. This chapter presents a spectrum of medical illnesses associated with CTS and their effects on treatment and prognosis.

Diabetes Mellitus

Diabetes mellitus affects the largest number of patients with CTS. The prevalence of CTS in diabetic patients is 15–25% [1], and up to 80% of type 1 DM patients will develop CTS over their lifetime [2]. According to a recent meta-analysis, type 1 or type 2 DM is associated with a twofold increased risk of CTS [3].

DM patients are also more likely to develop other neuropathies such as sensorimotor polyneuropathy. Nerve conduction studies can differentiate between patients with diabetic polyneuropathy and compression from carpal tunnel syndrome, and many patients will have both. Perkins et al. reported that CTS is present in 2% of the general population, 14% of DM patients without diabetic polyneuropathy, and 30% of DM patients with polyneuropathy [4].

Corticosteroid injection may relieve CTS symptoms in DM patients, but practitioners should warn patients that the corticosteroid can elevate their blood glucose for several days. Kim et al. found that 80% of DM patients had elevated blood glucose levels for up to 5 days following an injection of 10 mg of triamcinolone [5]. Corticosteroid injections may be less effective in DM patients, as DM patients were more likely than non-DM patients to undergo carpal tunnel release (CTR) for recurrent symptoms after corticosteroid injection [6].

Diabetic patients can expect similar results after CTR as nondiabetic patients, although their recovery may be slightly slower. Thomsen et al. found no difference in sensation, strength, patient satisfaction, or patient-reported outcomes between DM and non-DM groups 5 years after CTS surgery [7, 8]. One year after surgery, DM patients were more likely to complain of cold intolerance, but this difference resolved by the 5-year follow-up [7, 8]. Likewise, Cagle et al. found that diabetic patients improved more slowly but had similar functional results to non-DM patients 6 weeks after surgery [9].

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There is no evidence to support routine use of prophylactic antibiotics in DM patients undergoing CTR. Harness reported very low infection rates after CTR in both diabetic (0.55%) and non-diabetic patients (0.33%) and no difference between those treated with prophylactic antibiotics and those without [10].

Hypothyroidism

Estimates of the association between CTS and hypothyroidism vary. Oktayoglu reported 32.5% of patients being treated for hypothyroidism met criteria for CTS based on electrophysiological studies [11]. Eslamian et al. also identified CTS based on electrophysiological studies in 32.5% of 40 patients with untreated hypothyroidism [12]. In contrast, Shiri's meta-analysis found a modest association between hypothyroidism and suggested that the association may be exaggerated by publication bias [13].

Although patients with hypothyroidism may have CTS, screening all patients with CTS for hypothyroidism is low yield. De Rijk et al. identified two new cases of hypothyroidism out of 516 patients with CTS and no known history of hypothyroidism [14]. Similarly, Vashishtha et al. diagnosed two new cases of hypothyroidism among 100 patients indicated for carpal tunnel release [15].

Treatment with thyroid replacement can improve nerve function on electrophysiologic testing [16, 17]. Kececi found statistically significant changes in median motor distal latency and amplitude and median sensorial nerve conduction velocity after 3 months of thyroid replacement treatment [16]. Unfortunately, in most hypothyroid patients, CTS symptoms persist even after appropriate treatment with thyroid replacement [17].

No studies directly address the role of bracing, steroid injection, or carpal tunnel release in hypothyroid CTS patients.

Acromegaly

Acromegaly results from excessive secretion of growth hormone, commonly due to a pituitary adenoma. The majority of acromegaly patients will demonstrate electrophysiologic changes in the median nerve at the wrist, although they may or may not report CTS symptoms [11]. MRI studies of acromegaly patients with CTS demonstrate enlargement of the median nerve [18].

Although a high percentage of acromegaly patients will have CTS, acromegaly is sufficiently rare that screening CTS patients for elevated growth hormone is not indicated. Zoicas et al. screened 196 patients indicated for CTR and found no patient with acromegaly [19].

Treatment of the underlying cause of acromegaly can decrease CTS symptoms [18, 20]. Sasagawa et al. noted improvement in nerve conduction velocities and patient-reported symptoms one year after adenoma resection in seven of eight patients with acromegaly and CTS [18]. In a group of four acromegaly patients with persistent CTS after treatment for elevated growth hormone, Iwasaki reported successful symptom relief with carpal tunnel release [21].

Obesity

Increased BMI and obesity have been linked to carpal tunnel syndrome. In a recent meta-analysis of 58 studies, obese patients had a twofold increased risk of CTR. That same study estimated that each one unit increase in BMI correlated with a 7.4% increase in CTS and increased the risk of CTR by 7.4% [22].

However, obese patients are also more likely to have other comorbidities that can contribute to CTS risk. Specifically, those obese patients that meet criteria for metabolic syndrome (Table 6.1) tend to have more severe CTS than those who have diabetes or obesity alone [23]. Mondelli et al. also identified truncal obesity measured by

Table 6.1 Criteria for metabolic syndrome

Central obesity (waist circumference > 102 cm in males and >88 cm in females)
Hypertriglyceridemia (triglycerides ≥ 150 mg/dL)
Low serum HDL-C (<40 mg/dL in males and <50 mg/dL in females)
Hypertension (blood pressure ≥ 130/85 mm Hg or taking antihypertensive medication)
Fasting plasma glucose ≥ 100 mg/dL

waist circumference/hip circumference as a risk factor for CTS [24].

Few studies examine the effect of weight loss on CTS symptoms. Kurt et al. found no improvement in median nerve conduction despite 3 months of weight loss in obese patients [25]. Castro Ado et al. identified no difference in CTS prevalence between patients awaiting bariatric surgery and those who had undergone bariatric surgery [26].

Rheumatoid Arthritis

Rheumatoid arthritis (RA) may be associated with an increased incidence of CTS, although study results vary. Karadag identified ultrasound evidence of CTS in 17 of 100 women with RA compared to 4% of age-matched controls [27]. In a larger study of 1070 RA patients, the CTS incidence was 4.2 per 1000 person-years which is very similar to the rate in the general population [28].

Practitioners should not assume upper extremity numbness in RA patients is due to CTS as nerve dysfunction can result from several different mechanisms associated with RA. Cervical spine instability or degeneration can lead to nerve dysfunction. In addition, damage to the nerve vascular supply can cause neuropathy not associated with compression. Some patients may experience a "double crush" if there are multiple points of nerve compression or damage [29].

Few studies describe outcomes after CTS treatment in RA patients. Muramatsu et al. reported mostly good and excellent results after CTR in 15 patients [29], and they suggested doing flexor tenosynovectomy only in those with florid tenosynovitis. Belcher et al. reported good results following endoscopic CTR with no tenosynovectomy in "selected" RA patients (seropositive but clinically well controlled) [30].

Gout

Gout is not a common cause of CTS, but gout patients can experience deposition of monosodium urate crystals in the soft tissues in and around the carpal tunnel. Wrist MR in patients with tophaceous gout identified tophi in the floor of the carpal tunnel, flexor tendons, wrist joint, and extensor tendons [31]. Gouty tophi and liquefied tophi have been implicated in several cases of acute carpal tunnel syndrome [32]. Although it may be indicated to relieve pressure on the nerve, carpal tunnel release in the setting of tophaceous gout can lead to poor wound healing and persistent drainage [31, 32].

Pregnancy

Between one third and one half of women will report CTS symptoms during pregnancy, and approximately 17% will have electrophysiologic evidence of CTS [33, 34]. Typically, symptoms worsen during the course of the pregnancy and are most severe in the third trimester [25]. After 30 weeks, most pregnant women experience an increase in extravascular fluids (fluid retention) which likely contributes to median nerve compression [25]. A recent review found that 50% of patients still report symptoms 1 year after delivery and 30% will still have symptoms 3 years postpartum [35].

Nighttime bracing, steroid injection, and carpal tunnel release surgery are all treatment options for pregnant patients. In one study of 20 pregnant women with CTS, injection with dexamethasone and lidocaine both decreased symptoms and improved their electrophysiologic exam. No study has directly examined the safety of carpal tunnel steroid injection during pregnancy, but no complications have been reported from this treatment [34].

If possible, surgery should be avoided during pregnancy because symptoms will often resolve after delivery. However, if necessary, carpal tunnel release can be performed under local anesthetic with a tourniquet. Assmus and Hashemi found 98% of 133 pregnant patients reported good or excellent results after CTR [36].

Infectious Conditions

A variety of atypical infectious organisms can lead to CTS, including mycobacteria and fungi. In most of these cases, patients experience a

slowly developing swelling over the volar wrist and median nerve dysfunction. Advanced imaging such as MRI will reveal thickening of the flexor tenosynovium, but cannot differentiate between infectious and other causes of tenosynovitis such as rheumatoid arthritis. Significant asymmetric swelling over the flexor tendons or a history of immune compromise should prompt consideration of atypical infection, and biopsy of inflammatory tenosynovial tissue should be obtained for fungal and AFB cultures.

Tuberculosis in the hand most commonly presents as slowly progressive flexor tenosynovitis [37]. The tenosynovitis appears as swelling proximal and distal to the transverse carpal ligament and sometimes communicates with the radial or ulnar bursa. Rice bodies may be seen upon opening the carpal tunnel. Treatment consists of operative decompression and debridement along with antituberculosis antibiotics [38]. Delay in diagnosis and treatment can lead to flexor tendon rupture. Most patients will not have systemic or pulmonary manifestations of their tuberculosis infection [37].

Fungal infection with *Histoplasma capsulatum* or *Sporothrix schenckii* can also cause flexor tenosynovitis and associated CTS [39, 40]. *Histoplasma capsulatum* can be found in cat and bat feces and is endemic to portions of North, Central, and South America. The majority of patients with reported cases of CTS due to histoplasmosis occurred in immunocompetent patients [41]. *Sporothrix schenckii* typically causes a lymphocutaneous infection following inoculation of the hand or arm from a plant puncture, but can cause a proliferative tenosynovitis in the carpal tunnel [42].

Amyloidosis

Certain forms of amyloidosis can cause CTS. Thirty-eight percent of patients with Finnish gelsolin amyloidosis (also known as Meretoja syndrome) reported CTS symptoms [39]. This autosomal dominant syndrome consists of eye problems (corneal lattice dystrophy), lax facial skin (cutis laxa), and paresis of facial nerves. One quarter of patients in the Finnish gelsolin amyloidosis registry underwent carpal tunnel release surgery.

Some researchers suggest that amyloid deposition may contribute to so-called idiopathic CTS. Uchiyama et al. reported some degree of wild-type transthyretin amyloid was present in the tenosynovium of 34% of patients undergoing CTR for presumed idiopathic CTS, which was higher than age-matched controls. This type of amyloid deposition is known to be age related. The presence of amyloid did not impact functional outcome after CTR in the patients with amyloid deposition [40, 43].

Mucopolysaccharide Storage Diseases

Mucopolysaccharide storage diseases (MPSD) can cause both trigger digits and carpal tunnel syndrome in children. Deficiency in 1 of 11 enzymes necessary for breakdown of glycosaminoglycans (GAGs) results in systemic deposition of GAGs (Table 6.2). In the hand, this manifests as skeletal dysplasia as well as thickening of the flexor retinaculum, tenosynovium, and epineurium [44]. Although hematopoietic stem cell transplantation and enzyme replacement therapy mitigate many MSPD manifestations, these therapies do not seem to prevent or cure CTS [45].

MPSD patients rarely present with typical CTS complaints of numbness and paresthesias, but may exhibit behaviors such as clumsiness, gnawing of hands, withdrawal of hands from others, and nighttime waking [44].

MPSD should be considered in any child presenting with CTS. If initial urine testing reveals excessive urinary excretion of glycosaminoglycans, the patient should be referred to a geneticist for a complete evaluation. In a patient with a known diagnosis of MPSD, Holt et al. recommend screening for CTS beginning at age 3 [44]. Using the adjacent ulnar nerve as a control, nerve conduction values can confirm the diagnosis of CTS. Treatment for CTS should include carpal tunnel release through an extended carpal tunnel incision combined with flexor tenosynovectomy

Table 6.2 Enzyme deficiencies in mucopolysaccharide storage diseases

Type	Common name	Deficient enzyme	Accumulated products
MPS I H MPS I H/S MPS I S	Hurler Hurler-Scheie Scheie	Alpha-L-iduronidase	Heparan sulfate Dermatan sulfate
MPS II	Hunter	Iduronate-2-sulfatase	Heparin sulfate Dermatan sulfate
MPS III A MPS III B MPS IIIC MPS IIID MPS IIIE	Sanfilippo	Sulfamidase Alpha-*N*-acetylglucosaminidase Acetyl-CoA-glucosaminide-acetyltransferase *N*-acetylglucoosamine-6-sulfatase *N*-glucosamine 3-*O*-sulfatase	Heparin sulfate
MPS IV A-B	Morquio	*N*-acetylgalactosamine-6-sulfatase Beta-galactosidase	Keratin/chondroitin sulfate
MPS VI	Maroteaux-Lamy	Arylsulfatase B	Dermatan sulfate
MPS VII	Sly	Beta-glucuronidase	Heparan sulfate Dermatan sulfate Chondroitin 4,6-sulfate
MPS IX	Natowicz	Hyaluronidase	Hyaluronic acid

and potentially excision of FDS tendons in severe cases. Nerve conduction changes may persist after surgical treatment.

Hemodialysis

Patients on hemodialysis for end-stage renal disease are at risk for developing carpal tunnel syndrome, although the exact incidence is not known. Increased extracellular fluid volume secondary to uremia, amyloid deposition in the soft tissues including the epineurium, and fluid shifts during hemodialysis contribute to CTS in HD patients [46]. CTS may occur in the arm with or without an arteriovenous fistula [46]. Although many patients require HD as the result of DM complications, CTS occurs regardless of the cause of their renal disease, and the likelihood of developing CTS correlates with the duration of hemodialysis [47].

Most hemodialysis patients who undergo CTR will experience a decrease in symptoms. Kang et al. reported a higher incidence of wound healing problems and recurrent CTS in hemodialysis patients compared to age-matched patients with idiopathic CTS. In that study, 30 of 36 hemodialysis patients reported fewer CTS symptoms 2 years after CTR [47].

Conclusion

Although most patients will have idiopathic CTS, surgeons should recognize associated medical conditions and their impact on treatment and prognosis.

References

1. Chammas M, Bousquet P, Renard E, Poirier JL, Jaffiol C, Allieu Y. Dupuytren's disease, carpal tunnel syndrome, trigger finger, and diabetes mellitus. J Hand Surg Am. 1995;20:109–14.
2. Singh R, Gamble G, Cundy T. Lifetime risk of symptomatic carpal tunnel syndrome in Type 1 diabetes. Diabet Med. 2005;22:625–30.
3. Pourmemari MH, Shiri R. Diabetes as a risk factor for carpal tunnel syndrome: a systematic review and meta-analysis. Diabet Med. 2016;33:10–6.
4. Perkins BA, Olaleye D, Bril V. Carpal tunnel syndrome in patients with diabetic polyneuropathy. Diabetes Care. 2002;25:565–9.
5. Kim N, Schroeder J, Hoffler CE, Matzon JL, Lutsky KF, Beredjiklian PK. Elevated hemoglobin A1C levels correlate with blood glucose elevation in diabetic patients following local corticosteroid injection in the hand: a prospective study. Plast Reconstr Surg. 2015;136:474e–9e.
6. Jenkins PJ, Duckworth AD, Watts AC, McFachan JE. Corticosteroid injection for carpal tunnel syndrome: a 5 year survivorship analysis. Hand (NY). 2012;7:151–6.

7. Thomsen NOB, Cederlund RI, Andersson GS, Rosen I, Bjork J, Dahlin LB. Carpal tunnel release in patients with diabetes: a 5 year follow-up with matched controls. J Hand Surg Am. 2014;39:713–20.
8. Thomsen NO, Cederlund R, Bjork J, Dahlin LB. Clinical outcomes of surgical release among diabetic patients with carpal tunnel syndrome: prospective follow-up with matched controls. J Hand Surg Am. 2009;34:1177–87.
9. Cagle PJ, Reams M, Agel J, Bohn D. An outcomes protocol for carpal tunnel release: a comparison of outcomes in patients with and without medical comorbidities. J Hand Surg Am. 2014;39:2175–80.
10. Harness NG, Inacio MC, Pfeil FF, Paxton LW. Rate of infection after carpal tunnel release surgery and effect of antibiotic prophylaxis. J Hand Surg. 2010;35: 189–96.
11. Oktayoglu P, Nas K, Kilinc F, Tasdemir N, Bozkurt M, Yildiz I. Assessment of the presence of carpal tunnel syndrome in patients with diabetes mellitus, hypothyroidism and acromegaly. J Clin Diagn Res. 2015;9: OC14–8.
12. Eslamian F, Bahrami A, Aghamohammadzadeh N, Niafar M, Salekzamani Y, Behkamrad K. Electrophysiologic changes in patients with untreated primary hypothyroidism. J Clin Neurophysiol. 2011;28:323–8.
13. Shiri R. Hypothyroidism and carpal tunnel syndrome: a meta-anlysis. Muscle Nerve. 2014;50:879–83.
14. de Rijk MC, Vermeij FH, Suntjens M, van Doorn PA. Does a carpal tunnel syndrome predict an underlying disease? J Neurol Neurosurg Psychiatry. 2007;78: 635–7.
15. Vashishtha M, Varghese B, Mosley F, Kadakla A, de Jager W. Screening for thyroid dysfunction and diabetes in patients with carpal tunnel syndrome. Surgeon. 2016;14:147–9.
16. Kececi H, Degirmenci Y. Hormone replacement therapy in hypothyroidism and nerve conduction study. Neurophysiol Clin. 2006;36:79–83.
17. Palumbo CF, Szabo RM, Olmsted SL. The effects of hypothyroidism and thyroid replacement on the development of carpal tunnel syndrome. J Hand Surg Am. 2000;25:734–9.
18. Sasagawa Y, Tachibana O, Doai M, Tonami H, Iizuka H. Median nerve conduction studies and wrist magnetic resonance imaging in acromegalic patients with carpal tunnel syndrome. Pituitary. 2015;18:695–700.
19. Zoicas F, Kleindienst A, Mayr B, Buchfelder M, Megele R, Schöfl C. Screening for acromegaly in patients with carpal tunnel syndrome: a prospective study (ACROCARP). Horm Metab Res. 2016;48: 452–6.
20. Baum Baum H, Ludecke DK, Herrmann HD. Carpal tunnel syndrome and acromegaly. Acta Neurochir. 1986;83:54–5.
21. Iwasaki N, Masuko T, Ishikawa J, Minami A. Surgical efficacy of carpal tunnel release for carpal tunnel syndrome in acromegaly: report of four patients. J Hand Surg Br. 2005;30:605–6.
22. Shiri R, Pourmemari MH, Falah-Hassani K, Viikari-Juntura E. The effect of excess body mass on the risk of carpal tunnel syndrome: a meta-analysis of 58 studies. Obes Rev. 2015;16:1094–104.
23. Gül Yurdakul F, Bodur H, Öztop Çakmak Ö, Ateş C, Sivas F, Eser F, Yılmaz Taşdelen Ö. On the severity of carpal tunnel syndrome: diabetes or metabolic syndrome. J Clin Neurol. 2015;11:234–40.
24. Mondelli M, Aretini A, Ginanneschi F, Greco G, Mattioli S. Waist circumference and waist-to-hip ratio in carpal tunnel syndrome: a case-control study. J Neurol Sci. 2014;338:207–13.
25. Kurt S, Kisacik B, Kaplan Y, Yildirim B, Etikan I, Karaer H. Obesity and carpal tunnel syndrome: is there a causal relationship? Eur Neurol. 2008;59: 253–7.
26. Castro Ado A, Skare TL, Nassif PA, Sakuma AK, Ariede BL, Barros WH. Ultrasound evaluation on carpal tunnel syndrome before and after bariatric surgery. Rev Col Bras Cir. 2014;41:426–33.
27. Karadag O, Kalyoncu U, Akdogan A, Karadag YS, Bilgen SA, Ozbakır S, Filippucci E, Kiraz S, Ertenli I, Grassi W, Calgüneri M. Sonographic assessment of carpal tunnel syndrome in rheumatoid arthritis: prevalence and correlation with disease activity. Rheumatol Int. 2012;32:2313–9.
28. Lee KH, Lee CH, Lee BG, Park JS, Choi WS. The incidence of carpal tunnel syndrome in patients with rheumatoid arthritis. Int J Rheum Dis. 2015;18:52–7.
29. Muramatsu K, Tanaka H, Taguchi T. Peripheral neuropathies of the forearm and hand in rheumatoid arthritis: diagnosis and options for treatment. Rheumatol Int. 2008;28:951–7.
30. Belcher HJ, Varma S, Schonauer F. Endoscopic carpal tunnel release in selected rheumatoid patients. J Hand Surg Br. 2000;25:451–2.
31. Clement KH, Chen CK, Chung CB, Yeh L, Pan HB, Yang CF, Lai PH, Liang HL, Resnick D. Carpal tunnel syndrome caused by tophaceous gout: CT and MR Imaging features in 20 patients. AJR. 2000;175: 655–9.
32. Carr L, Brooke S, Ingraham J. Medically managed gout precipitating acute carpal tunnel syndrome. Hand (NY). 2015;10:574–7.
33. Meems M, Truijens S, Spek V, Visser LH, Pop V. Prevalence, course and determinants of carpal tunnel syndrome symptoms during pregnancy: a prospective study. BJOG. 2015;122:1112–8.
34. Moghtaderi AR, Mohgtaderi N, Loghmani A. Evaluating the effectiveness of local dexamethasone injection in pregnant women with carpal tunnel syndrome. J Res Med Sci. 2011;16:687–90.
35. Padua L, Di Pasquale A, Pazzaglia C, Liotta GA, Librante A, Mondelli M. Systematic review of pregnancy-related carpal tunnel syndrome. Muscle Nerve. 2010;42:697–702.
36. Assmus H, Hashemi B. Surgical treatment of carpal tunnel syndrome in pregnancy: results from 314 cases. Nervenarzt. 2000;71:470–3.

37. Al-Qattan MM, Al-Namla A, Al-Thunayan A, Al-Omawi M. Tuberculosis of the hand. J Hand Surg Am. 2011;36:1413–21.
38. Hassanpour SE, Gousheh J. Mycobacterium tuberculosis-induced carpal tunnel syndrome: management and follow-up evaluation. J Hand Surg Am. 2006;31:575–9.
39. Nikoskinen T, Schmidt EK, Strbian D, Kiuru-Enari S, Atula S. Natural course of Finnish gelsolin amyloidosis. Ann Med. 2015;47:506–11.
40. Uchiyama S, Sekijima Y, Tojo K, Sano K, Imaeda T, Moriizumi T, Ikeda S, Kato H. Effect of synovial transthyretin amyloid deposition on preoperative symptoms and postoperative recovery of median nerve function among patients with idiopathic carpal tunnel syndrome. J Orthop Sci. 2014;19:913–9.
41. Vitale MA, Roden AC, Rizzo M. Tenosynovitis of the wrist and thumb and carpal tunnel syndrome caused by Histoplasma capsulatum: case report and review of the literature. Hand. 2015;10:54–9.
42. Stratton CW, Lichtenstein KA, Lowenstein SR, Phelps DB, Reller LB. Granulomatous tenosynovitis and carpal tunnel syndrome caused by *Sporothrix schenckii*. Am J Med. 1981;71:161–4.
43. Sekijima Y, Uchiyama S, Tojo K, Sano K, Shimizu Y, Imaeda T, Hoshii Y, Kato H, Ikeda S. High prevalence of wild-type transthyretin deposition in patients with idiopathic carpal tunnel syndrome: a common cause of carpal tunnel syndrome in the elderly. Hum Pathol. 2011;42:1785–91.
44. Holt JB, Van Heest AE, Shah AS. Hand disorders in children with mucopolysaccharide storage diseases. J Hand Surg. 2013;381:2263–6.
45. Khanna G, Van Heest AE, Agel J, et al. Analysis of factors affecting development of carpal tunnel syndrome in patients with Hurler syndrome after hematopoietic cell transplantation. Bone Marrow Transplant. 2007;39:331–4.
46. Minami A, Ogino T. Carpal tunnel syndrome in patients undergoing hemodialysis. J Hand Surg Am. 1987;12A:93–7.
47. Kang HJ, Koh IH, Lee WY, Choi YR, Hahn SB. Does carpal tunnel release provide long-term relief in patients with hemodialysis-associated carpal tunnel syndrome? Clin Orthop Relat Res. 2012;470:2561–5.