The Relationship Between Sustained Gripping and the Development of Carpal Tunnel Syndrome

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An examination of clinical and electrodiagnostic assessments and fully characterized individual hand usage patterns finds a relationship between sustained gripping and the development of carpal tunnel syndrome in the nondominant hand.

The dominant limb is the limb preferred for performing an activity that requires one hand or for performing the more demanding part of an activity that requires both hands. For example, most playing card dealers use their dominant limb to distribute cards (the more demanding part of the activity) and their nondominant limb to hold the rest of the pack (the less demanding activity). Although a relationship between nocturnal hand paresthesias and daily hand activities has been known for more than a century, it was not until more recently that it was recognized that unilateral carpal tunnel syndrome (CTS) more commonly involves the dominant limb.[1,2]

Among people with CTS, the dominant limb tends to be affected earlier and, in the setting of bilateral involvement, more severely.[3,4] This relationship, however, is not absolute. In 1983, Falck and Aarnio reported that CTS could be more pronounced on the nondominant side whenever upper extremity usage requirements, especially occupational requirements, stressed that limb to a greater extent than they stressed the dominant limb.[5]

Regarding occupation, particular CTS risk factors and associations have been reported. One study found that the most common work-related risk factor was repetitive bending and twisting of the hands and wrists.[6] In another study, the incidence of CTS was almost 10-fold higher among workers performing high force, high repetition jobs than among those performing low force, low repetition jobs.[7-10] A meta-analysis identified a strong causal relationship between forceful, repetitive work and development of CTS.[11] A more recent and controversial study found no association between heavy use of computers and CTS.[12] In 1911, Hart reported an association between repetitive gripping and thenar atrophy.[13] Although he misattributed the association to trauma of the recurrent thenar motor branch, 2 of the 3 described patients reported a period of episodic hand paresthesias preceding the development of thenar eminence atrophy and thus more likely had typical CTS.

BACKGROUND

The present study was prompted by the clinical and electrodiagnostic (EDX) features of a 27-year-old right-hand–dominant man who presented to the EDX laboratory for assessment of bilateral hand paresthesias. The patient reported episodic bilateral hand tingling that was much more pronounced on the left (nondominant) side. Consistent with his report, EDX assessment revealed bilateral CTS that involved the nondominant limb to a much greater extent than that of the dominant limb. As a blackjack dealer, the patient was using his nondominant hand to "tightly grip 2 decks of cards" and the dominant hand to distribute those cards.

Similar history and EDX patterns (bilateral CTS more pronounced on nondominant side) were subsequently noted in 2 other patients, both of whom were using their nondominant limb to perform an activity that required sustained gripping. One of these patients was a minnow counter. He was using his nondominant hand to firmly grip the top of a bucket and the dominant hand to "deal" the fish into separate tanks. The other patient was a mason. He

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Table 1. Electrodiagnostic Results of 21 Patients With Backward Carpal Tunnel Syndrome

Pt	Age, y	Handedness	Sex	Distribution	Median Palmar				Median Index Finger				Median Thenar Eminence			
					L	R	Δ	Normal	L	R	Δ	Normal	L	R	Δ	Normal
1	59	R	F	L only	3.8	1.8	2.0	< 2.2 in each case	4.1	2.9	1.2	< 3.6	5.0	3.2	1.8	< 4.0
2	55	R	M	L > R	NR	3.1	NA		NR	4.1	NA	< 3.6	7.9	4.2	3.7	< 4.0
3	41	R	F	L > R	2.9	2.3	0.6		4.2	3.4	0.8	< 3.4	4.3	3.3	1.0	< 3.9
4	61	R	F	L only	2.8	2.2	0.6		4.0	3.3	0.7	< 3.8	4.0	3.6	0.4	< 4.0
5	52	L	F	R only	2.4	1.7	0.7		3.6	2.6	1.0	< 3.6	3.5	3.1	0.4	< 4.0
6	53	R	F	L > R	3.5	2.7	0.8		4.9	4.1	0.8	< 3.6	4.8	4.0	0.8	< 4.0
7	33	R	F	L only	3.8	1.7	2.1		4.1	2.6	1.5	< 3.4	4.3	2.7	1.6	< 3.9
8	53	R	F	L > R	4.1	3.2	0.9		5.4	4.7	0.7	< 3.6	5.8	5.6	0.2	< 4.0
9	37	R	M	L > R	4.0	2.3	1.7		4.8	3.3	1.5	< 3.4	4.2	3.1	1.1	< 3.9
10	32	L	F	R > L	3.5	2.9	0.6		4.6	3.8	0.8	< 3.4	5.6	4.3	1.3	< 3.9
11	51	R	M	L only	2.8	1.9	0.9		3.9	3.1	0.8	< 3.6	4.4	3.8	0.6	< 4.0
12	34	R	F	L only	2.8	1.9	0.9		4.2	3.0	1.2	< 3.4	4.4	3.1	1.3	< 3.9
13	37	R	M	L > R	3.4	2.5	0.9		4.6	3.8	0.8	< 3.4	5.1	3.9	1.2	< 3.9
14	38	R	F	L > R	NR	2.9	NA		5.2	4.2	1.0	< 3.4	4.5	4.0	0.5	< 3.9
15	48	R	M	L > R	4.3	2.3	2.0		4.9	3.7	1.2	< 3.4	5.5	3.7	1.8	< 3.9
16	55	R	F	L > R	NR	2.9	NA		NR	4.1	NA	< 3.6	4.8	4.3	0.5	< 4.0
17	57	R	F	L > R	NR	3.5	NA		NR	4.8	NA	< 3.6	7.8	5.5	2.3	< 4.0
18	72	R	M	L > R	NR	2.9	NA		NR	4.4	NA	< 3.8	NR	4.4	NA	< 4.0
19	79	R	F	L > R	NR	2.3	NA		5.6	3.4	2.2	< 3.8	7.1	3.3	3.8	< 4.0
20	63	R	F	L > R	NR	2.7	NA		NR	3.8	NA	< 3.8	8.3	4.0	4.3	< 4.0
21	56	R	F	L > R	3.6	2.3	1.3		5.0	3.5	1.5	< 3.6	4.5	3.8	0.7	< 4.0

Abbreviations: F, female; L, left; M, male; NA, not applicable; NR, no response; PT, patient; R, right.

was using his nondominant hand to firmly hold a brick or stone in place and the dominant hand to apply cement. The clinical and EDX features of these 3 patients suggested that sustained gripping might be a significant risk factor for development of CTS. That all 3 of these patients were using their dominant hand for a repetitive activity (dealing) further suggested that, compared with repetitive activity, sustained gripping was more significant as a risk factor for development of CTS.

As unilateral CTS typically occurs on the dominant side, and bilateral CTS typically is more pronounced on the dominant side, the term *backward CTS* is applied to cases in which unilateral CTS occurs on the nondominant side or bilateral CTS involves the nondominant side to a greater extent than the dominant side.

Although many investigators have purported an association between CTS and a particular upper extremity activity, their conclusions are limited by use of poorly validated symptom surveys, use of faulty epidemiologic methods, selection of a specific basis for clinical diagnosis (eg, isolated hand pain), or lack of EDX confirmation. Associations between a particular activity and development of CTS are best addressed by

studies that include both clinical and EDX assessments and that fully characterize the individual hand usage patterns.

METHODS

This study identified the upper extremity usage patterns associated with development of CTS among patients found in the EDX laboratory to have backward CTS (unilateral CTS in nondominant limb or bilateral CTS involving nondominant limb more than dominant limb). Thus, whenever patients who were referred to the EDX laboratory for upper extremity studies were noted to have backward CTS, an extensive upper extremity usage assessment was immediately performed. Both the EDX studies and the upper extremity usage assessments were performed by the author during the same encounter.

All patients had initial screening sensory and motor nerve conduction studies performed: median sensory, recording the second digit; ulnar sensory, recording the fifth digit; superficial radial, recording the dorsum of hand; median motor, recording the thenar eminence; and ulnar motor, recording the hypothenar eminence. As CTS was suspected in all cases, median and ulnar palmar nerve conduction studies were performed as well. All these studies were performed using previously reported techniques, and all collected values were compared with EMG laboratory control values.[14,15] In all patients, the median nerve conduction studies were performed bilaterally. Approval from an ethics board or an institutional review board was not needed because this study did not involve personal information or identifiable images.

To avoid identifying small, chance asymmetries related to hypothyroidism and other conditions that produce bilateral CTS, the author predefined the degree of asymmetry required for study inclusion to identify only large asymmetries. Because the EDX manifestations of CTS typically reflect features of demyelination before those of axon loss, the required asymmetries were predefined using peak sensory and distal motor latency values. For study inclusion, the median nerve latency value recorded from the nondominant limb needed to exceed the value recorded from the dominant limb by 0.6 msec for the median palmar responses, 1.0 msec for the median digital sensory responses, or 1.0 msec for the median motor responses.

Excluded from the study were patients who reported being ambidextrous, those who had changed hand dominance at any age and for any reason, those with a history of upper extremity trauma or surgery, and those with EDX findings indicating a concomitant neuromuscular disorder. In addition, patients with diabetes mellitus or any other condition associated with bilateral CTS were excluded.

RESULTS

From the approximately 2,000 upper extremity EDX studies performed over a 30-month period, the author identified 21 patients who met the inclusion criteria (Table 1). Of these 21 patients, 15 (71%) had bilateral CTS and 6 (29%) had unilateral CTS. Sixteen of the 21 patients used their nondominant hand, through a significant portion of the day, to perform an activity that required sustained gripping (Table 2).

Of these 16 patients, 14 reported that the sustained gripping activity was related to their occupation: pipe fitter (4 patients), card dealer (4), professional driver (2), grocery store clerk (1), wire stripper (1), bakery worker (1), and motel room cleaner (1). In their jobs, the pipe fitters were continually cutting pipe during their entire 8-hour shift—using the nondominant hand to tightly grip a pipe while using the dominant hand to direct an electrically powered blade through it. Of the card dealers, 1 was a professional playing card dealer (not the dealer whose case prompted this study), 1 distributed store coupons into containers, and 2 distributed pieces of mail into bins (referred to as *casing* the mail). All the card dealers used their nondominant hand to tightly grip items that the dominant limb distributed. The professional drivers used their nondominant hand to grip the steering wheel. The grocery store clerk used her nondominant hand to grip shopping items while moving them across a barcode detector. The wire stripper used her nondominant hand to tightly grip bundles of wire while holding a tool in the dominant hand to snip or strip them. The bakery worker continually used her nondominant hand to squeeze off pieces of dough from a mound. And the motel room cleaner used her nondominant hand to grip the side of a bathtub while scrubbing the tub with her dominant hand (she estimated she cleaned bathtubs for about 25% of her 8-hour shift).

Of the 2 patients who reported sustained gripping unrelated to occupation, 1 was baby-sitting her grandson 5 days per week. She carried him, grasping his buttock with her nondominant hand, while performing her daily activities. She estimated she carried the child a minimum of 2 hours a day. After several weeks, she noted episodic tingling in the nondominant hand, yet she continued carrying him for another

Table 2. Activities Responsible for Backward Carpal Tunnel Syndrome in 21 Patients

Patient	Occupation/Activity	Activity description
Reported sustained gripping related to occupation		
2, 11, 13, 15	Pipe fitter	Squeezing/holding pipe with nondominant hand while cutting with dominant hand
3	Card dealer—coupons	Holding coupons in nondominant hand while dealing with dominant hand
8	Card dealer—mail	Holding stack of mail with nondominant hand while "casing" with dominant hand
18	Card dealer—mail	Holding stack of mail with nondominant hand while "casing" with dominant hand 8 hours per day for 4.5 years
21	Card dealer—playing cards	Gripping deck(s) of cards with nondominant hand while dealing with dominant hand
7	Professional driver	Gripping cell phone with nondominant hand 3 to 5 hours per day
9	Professional driver	Driving with nondominant hand
6	Grocery store clerk	Moving items through barcode scanner with nondominant hand while operating register with dominant hand
20	Wire stripper	Holding wire with nondominant hand while cutting or stripping with tool held in dominant hand
16	Bakery worker	Pinching off dough with nondominant hand 2.5 hours per day 5 days per week for 8.5 years
14	Motel room cleaner	Holding side of bathtub with nondominant hand while scrubbing tub with dominant hand; driving with nondominant hand
Reported sustained gripping unrelated to occupation		
4	Grandmother	Holding grandson with nondominant hand by grasping his buttock
1	Stress relief class student	Opening and closing nondominant hand for 10 minutes multiple times per day
Denied activity that required sustained gripping		
5	Data entry worker	Entering data with nondominant hand 3 to 4 hours per day for 10 years
12	Data entry worker	Entering data with nondominant hand while using mouse with dominant hand
19	Piano teacher	Sitting to right of student while using nondominant hand to strike keys
10	Typist	Sleeping with nondominant hand flexed at face
17	Office worker	Denied sustained gripping or other activity involving nondominant limb; predominant duty is typing

7 months, at which point she sought medical care. The other patient, a student in a stress relief class, was instructed to repetitively open and tightly close her nondominant hand for 10 minutes 4 or more times per day. After several weeks, she noted episodic tingling in the exercised, nondominant hand.

Of the 5 patients who denied performing an activity that required sustained gripping, 2 used their nondominant limb to enter data into a computer while turning pages with the dominant limb. A piano teacher, used her nondominant limb to strike piano keys while sitting to the right of her pupils; and a typist, consistently slept with the dorsal aspect of the nondominant hand pressed into her cheek, resulting in sustained

wrist flexion throughout the night. One patient could not identify an activity performed with her nondominant limb both frequently and for prolonged periods.

DISCUSSION

As with other syndromic disorders, CTS is associated with several clinical features, the presence of which correlates with the severity of median nerve involvement. During the earliest stage of CTS, episodic hand tingling (a positive symptom) is commonly reported. This tingling typically is more pronounced at night and during relaxation. In addition, many patients come to recognize that their hand tingling is precipitated by activities that involve sustained upper extremity elevation (eg, driving with a limb resting on upper portion of steering wheel; reading with upper extremities maintained in forward abduction) and that lowering a symptomatic limb relieves its tingling.

With progression, negative symptoms appear (eg, numbness and then weakness and wasting). Unfortunately, as the negative symptoms replace the positive ones, affected individuals may become less symptomatic and mistakenly believe their condition is improving. Features of autonomic fiber involvement may also be present but are less reliably elicited. Isolated hand pain is an uncommon manifestation of CTS because pain more commonly occurs later in the course and for this reason tends to be accompanied by other features of CTS.

The clinical features of CTS correlate with its underlying pathology. As demyelination precedes axon disruption pathologically, the clinical features of demyelination (episodic paresthesias) precede those of axon loss (numbness, weakness, wasting). However, clinical features may go unrecognized or be dismissed by the patient. Moreover, there is substantial variation in type, intensity, and frequency of symptoms.[16,17]

The EDX features of CTS correlate with its underlying pathology and pathophysiology. As demyelination (loss of insulation) increases the capacitance of the membrane and increases internodal current leakage, conduction velocity is reduced. As severity worsens and pathology changes from predominantly demyelination to predominantly axon loss, the individual nerve fiber action potentials, which make up the compound responses being recorded, are lost. As a result the amplitude and negative area under the curve values decrease. Thus, the EDX features of demyelination (eg, prolonged latencies) precede those of axon loss (eg, amplitude, negative area under the curve reduction).

As with other focal mononeuropathies, the sensory responses tend to be affected earlier and to a greater degree than do the motor responses. Consequently, the EDX features of CTS typically follow a standard progression. The median palmar responses are involved sooner and to a greater degree than the median sensory responses recorded from the digits, which in turn tend to be involved earlier and to a greater degree than are the median motor responses.

Awareness of this relationship dictates the severity of the lesion and helps in the recognition of a cool limb and in the avoidance of a false-positive study interpretation. In a cool limb, the fingers are cooler than the wrists. Thus, the peak latency of the median digital sensory response is delayed to a greater extent than the ipsilateral median palmar response (the opposite of the CTS pattern). Accordingly, whenever this pattern is identified, the hand must be warmed or rewarmed and the studies repeated. The hand is also warmed or rewarmed whenever the median motor response is delayed out of proportion to that of the median palmar response.

CONCLUSION

Cases of CTS mainly in the nondominant limb provide an opportunity to identify particular limb usage patterns that might be associated with CTS. Of the present study's 21 affected patients, 16 were using their nondominant limb to perform activities that required sustained gripping. Fourteen of the 16 activities were related to occupation. These findings strongly suggest an association between activities that require sustained gripping and development of CTS.

That the card dealers simultaneously used their nondominant hand for sustained gripping and the dominant hand for the repetitive activity of dealing suggests that sustained gripping is a stronger risk factor than repetitive activity for the development of CTS—an unanticipated finding. Interestingly, in a 2001 study that suggested repetitive activity might not be a CTS risk factor, there was a higher incidence of CTS among computer users working with a mouse—an activity that requires sustained gripping.[12]

Episodic hand tingling during mouse use likely reflects impaired blood flow to the median nerve, which occurs when carpal tunnel pressure approaches or exceeds 20 to 30 mm Hg.[18] Placement of a hand on a mouse increases intracarpal pressure from 3 to 5 mm Hg (wrist in neutral position) to 16 to 21 mm Hg, whereas mouse use increases intracarpal pressure to 28 to 33 mm Hg.[18-20]

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REFERENCES

1. Ormerod JA. On a peculiar numbness and paresis of the hands. *St Barts Hosp Rep.* 1883;19:17-26.
2. Rosenbaum RB, Ochoa JL. *Carpal Tunnel Syndrome and Other Disorders of the Median Nerve.* 2nd ed. Boston, MA: Butterworth-Heineman; 2002.
3. Gainer JV Jr, Nugent GR. Carpal tunnel syndrome: report of 430 operations. *South Med J.* 1977;70(3):325-328.
4. Reinstein L. Hand dominance in carpal tunnel syndrome. *Arch Phys Med Rehabil.* 1981;62(5):202-203.
5. Falck B, Aarnio P. Left-sided carpal tunnel syndrome in butchers. *Scand J Work Environ Health.* 1983;9(3):291-297.
6. Tanaka S, Wild DK, Seligman PJ, Halperin WE, Behrens VJ, Putz-Anerson V. Prevalence and work-relatedness of self-reported carpal tunnel syndrome among U.S. workers: analysis of the Occupational Health Supplement data of 1988 National Health Interview Survey. *Am J Ind Med.* 1995;27(4):451-470.
7. Silverstein BA, Fine LJ, Armstrong TJ. Occupational factors and carpal tunnel syndrome. *Am J Ind Med.* 1987;11(3):343-358.
8. de Krom MC, Kester AD, Knipschild PG, Spaans F. Risk factors for carpal tunnel syndrome. *Am J Epidemiol.* 1990;132(6):1102-1110.
9. Hales TR, Bernard BP. Epidemiology of work-related musculoskeletal disorders. *Orthop Clin North Am.* 1996;27(4):679-709.
10. Roquelaure Y, Ha C, Pelier-Cady MC, et al. Work increases the incidence of carpal tunnel syndrome in the general population. *Muscle Nerve.* 2008;37(4):477-482.
11. Stock SR. Workplace ergonomic factors and the development of musculoskeletal disorders of the neck and upper limbs: a meta-analysis. *Am J Ind Med.* 1991;19(1):87-107.
12. Stevens JC, Witt JC, Smith BE, Weaver AL. The frequency of carpal tunnel syndrome in computer users at a medical facility. *Neurology.* 2001;56(11):1568-1570.
13. Hart JR. The thenar and hypothenar types of neural atrophy of the hand. *Am J Med Sci.* 1911;141:224-241.
14. Ferrante MA, Parry GJ, Wilbourn AJ. Sensory nerve conduction studies. Paper presented at: 51st Annual Meeting of the American Academy of Neurology; April 1999; Toronto, Canada.
15. Litchy WJ, Miller RG, Shields RW. Motor nerve conduction studies. Paper presented at: 51st Annual Meeting of the American Academy of Neurology; April 1999; Toronto, Canada.
16. Nunez F, Vranceanu AM, Ring D. Determinants of pain in patients with carpal tunnel syndrome. *Clin Orthop Relat Res.* 2010;468(12):3328-3332.
17. van Suchtelen M, Beck SJ, Gruber JS, Ring D. Progression of carpal tunnel syndrome according to electrodiagnostic testing in nonoperatively treated patients. *Arch Bone Jt Surg.* 2014;2(3):185-191.
18. Ghasemi-Rad M, Nosair E, Vegh A, et al. A handy review of carpal tunnel syndrome: from anatomy to diagnosis and treatment. *World J Radiol.* 2014;6(6):284-300.
19. Rydevik B, Lundborg G, Bagge U. Effects of graded compression on intraneural blood flow. An in vivo study on rabbit tibial nerve. *J Hand Surg Am.* 1981;6(1):3-12.
20. Keir PJ, Bach JM, Rempel D. Effects of computer mouse design and task on carpal tunnel pressure. *Ergonomics.* 1999;42(10):1350-1360.=