Carpal Tunnel Sonography by the Rheumatologist versus Nerve Conduction Study by the Neurologist

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ABSTRACT. ***Objective.*** To determine the value of sonography (SG) performed by the rheumatologist to diagnose carpal tunnel syndrome (CTS).

Methods. Sixty-three patients with clinical signs of CTS according to the neurologist, based on patient history and clinical examination, were studied. In the 6 weeks prior to surgery, SG was performed by a rheumatologist and nerve conduction study (NCS) was assessed. Improvement of initial complaints of 90% or more 3 months after surgery was considered to be the post-hoc gold standard for the diagnosis of CTS.

Results. After surgery, 47 patients (75%) experienced ≥ 90% relief of complaints. Mean cross sectional area of the median nerve for patients with CTS was 11.3 mm^2 compared to 6.1 mm^2 in the control group. The sensitivity to detect CTS was 0.70 for SG and 0.98 for NCS, and specificity was 0.63 for SG and 0.19 for NCS. Positive predictive value was 0.85 for SG and 0.78 for NCS; negative predictive value was 0.42 for SG and 0.75 for NCS. Accuracy was 0.68 for SG and 0.78 for NCS.

Conclusion. CTS can be identified by SG less sensitively but more specifically than by NCS. (J Rheumatol 2001;28:62–9)

Key Indexing Terms:
CARPAL TUNNEL SYNDROME SONOGRAPHY NERVE CONDUCTION STUDY
MEDIAN NERVE NERVE COMPRESSION SYNDROME RHEUMATOLOGIST

Carpal tunnel syndrome (CTS) can be disabling. In Holland, the prevalence of CTS was 9.2% for women and 0.6% for men[1]. Occupational CTS is a major cause of work loss and compensation in the USA[2]. The condition is attributed to compression of the median nerve in the carpal tunnel beneath the flexor retinaculum. A frequent phenomenon encountered in rheumatic patients is tendon sheath enlargement caused by synovial proliferation[3]. In patients with rheumatoid arthritis (RA) finger flexor tenosynovitis varies from 5 to 55%[4,5]. Among RA patients with finger flexor tenosynovitis, about 25–50% have CTS[6,7].

Imaging techniques such as magnetic resonance imaging (MRI)[8-10] and sonography (SG)[11,12] can be used to diagnose suspected CTS. Both have the advantage over nerve conduction study (NCS) that they provide information about the possible causes of CTS, such as RA tenosynovitis or synovitis of the wrist joint[13,14]. In the absence of CTS, SG might reveal the origin of hand pain in visualizing these changes.

MRI seems promising for diagnosis of CTS[8,9,15]. High resolution real-time SG was encouraging because compressed median nerve criteria were defined[11,16,17]. Imaging criteria for MRI and SG for CTS appeared to be about the same. The costs of SG investigation are about one-fifth the price of an MRI investigation. SG for diagnosis takes between 5 and 15 min, for an expert rheumatologist versus roughly 40 min for MRI.

It takes 6 months to train a rheumatologist to become an expert in SG if SG is performed frequently. A rheumatologist needs to perform about 200 sonograms every year on sonographic equipment with at least a 7.5 MHz or higher frequency transducer to maintain competence. Compared to MRI, SG is cheap, fast, and widely available, and can be performed in the rheumatology department.

We compared the diagnostic value of SG performed by the rheumatologist with that of NCS assessed by the neurologist, among patients with suspected CTS.

MATERIALS AND METHODS

We studied 63 consecutive patients [44 women, 19 men, mean age (SD) 52 (13) yrs; range 32–81; mean duration of complaints 21 (SD 20) mo; range 2–72] with clinical symptoms of CTS who visited the outpatient neurology

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clinic for complaints indicative of CTS who were asked to participate (Table 1). Of the 65 subjects, 2 were excluded at analysis due to polyneuropathy on the NCS. Informed consent was obtained from all patients. Patients were included by the neurologist (FB) only on the basis of patient history and examination. All patients had NCS and SG in the 6 weeks prior to surgery. No patient had prior surgery for CTS on the symptomatic side. As controls, 20 patients with unilateral right shoulder pain with no underlying rheumatic disease or sign/symptom of CTS were studied [15 women and 5 men, mean age 49 yrs (range 34–73)]; all had SG of their left hand. As most people are right handed and CTS mainly affects the dominant hand, we chose control patients with right shoulder pain and investigated the left wrists of this control group to minimize the change of asymptomatic CTS. NCS and surgery were not performed in the control group.

Gold standard. Improvement of initial complaints 3 months after surgery of at least 9 cm on a 10 cm visual analog scale (VAS) was considered to be the gold standard (≥ 90% relief of symptoms). Zero (0 cm) equaled no improvement and 10 (10 cm) total relief of all complaints. Since patients with CTS might also be present in the group of patients with < 90% relief of complaints, there is no fully objective criterion to make the diagnosis. The effect of treatment was also used by Grundberg[18]. The high cutoff point of 9 cm on the VAS excludes a possible placebo effect of the operation.

Sonography

Normal anatomy. The floor and sides of the entrance (proximal) of the carpal tunnel are formed by the navicular, lunate, triquetrum, and the pisiform bones (Figure 1). The osseous exit (distal) of the carpal tunnel is formed by the trapezium, trapezoid, capitate, and hamate bones. The surfaces of the carpal bones appear as bright white hyperechoic lines. The hyperechoic retinaculum flexorum forms the roof of the carpal tunnel. The retinaculum extends proximally from the navicular tubercle to the pisiform bone and distally from the tubercle of the trapezium bone to the hook of the hamate bone. The thickest portion of the retinaculum is found at the level of the exit of the carpal tunnel. Ten tubular structures form the contents of the carpal tunnel: 4 deep and 4 superficial flexor tendons, the flexor pollicis longus tendon, and the median nerve, which passes through the superficial radial part of the tunnel (Figure 1). The median nerve is visualized as a fine fibrillar structure. A hyperechoic rim usually forms the outline of the median nerve, possibly representing the perineural tissue (Figures 2 and 4). The echogenicity of the nerve and other structures, however, depends heavily on the angle of the ultrasound beam. If the ultrasound beam is not directed perpendicular to the region of interest, one might even obtain a false hypoechogenic picture because the reflected beam will not reach the transducer. This artificial hypoechogenicity is called anisotropy.

Tendons (hyperechoic and fibrillar structures) and nerves (less hyperechoic and finer fibrillar structures) can be discriminated quite easily[19,20]. The synovial sheaths around the flexor tendons appear as thin hypoechoic lines.

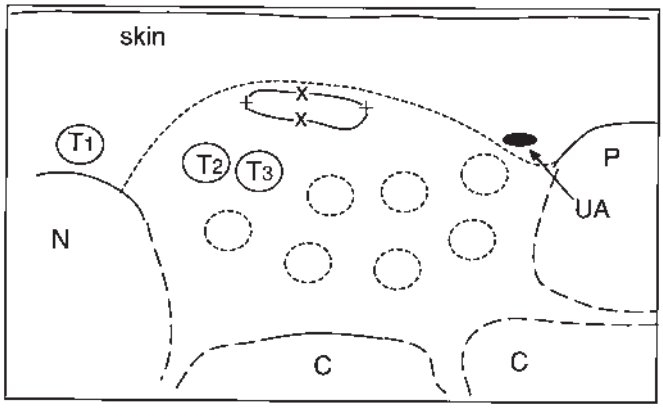

Figure 1. Transverse view of the entrance to the carpal tunnel with a normal median nerve. Navicular bone (N) and pisiform bone (P) together form the bony sides of the entrance (proximal). Two other carpalia (C) form the bottom of the entrance. T1: tendon of the flexor carpi radialis. T2: tendon of the flexor pollicis longus. T3: tendon of the flexor digitorum communis, in particular of the index finger. The other flexor tendons (superficial and deep) are shown as circles. UA: ulnar artery. Between N and P, a broken line represents the flexor retinaculum. + and x indicate the median nerve just below the flexor retinaculum.

Abnormal anatomy. In tendinitis and tenosynovitis, tendons often appear swollen and less hyperechoic; they are surrounded by effusion (anechoic) and synovial proliferation (hypoechoic), which are quite easily visualized on SG[21]. Separate from the carpal tunnel contents, the flexor carpi radialis tendon (Figures 1–4: T1) is found on top of the navicular bone on the radial side of the median nerve. Outside, at the ulnar side of the carpal tunnel, the ulnar artery (UA) and more laterally the ulnar nerve can be found. The median nerve is best identified on transverse images (Figures 1–4). The superficial flexor tendon of the index finger (Figures 1–4: T3) can be used as a landmark: it lies far below the median nerve and is easily distinguished from other flexor digitorum tendons, the flexor pollicis longus tendon (Figures 1–4: T2), and the median nerve by asking the patient to move individual fingers.

SG was performed in the 6 weeks prior to surgery with a real-time scanner (Aloka SSD 2000, Aloka, Tokyo, Japan) by a rheumatologist (WAAS) experienced in this technique. A 10 mHz linear array transducer was used.

In SG literature on CTS, 3 criteria have been described for transverse (axial) scans of the carpal tunnel: swelling of the medial nerve, the flattening ratio, and increased palmar bowing of the flexor retinaculum. The

Table 1. Clinical data of 63 patients.

	N	Mean (SD)	Range
Age in years		52 (13)	32–81
Female	44		
Male	19		
Disease duration in months		21 (20)	2–72
Concomitant diseases:			
Diabetes mellitus	6		
Hyperthyroidism	3		
Hypothyroidism	4		
Operated hand (right/left)	56/7		
Bilateral involvement of CTS*	38		
Success of operation** (%)	47 (75)		

*The most symptomatic hand was operated upon. **≥ 90% relief of symptoms.

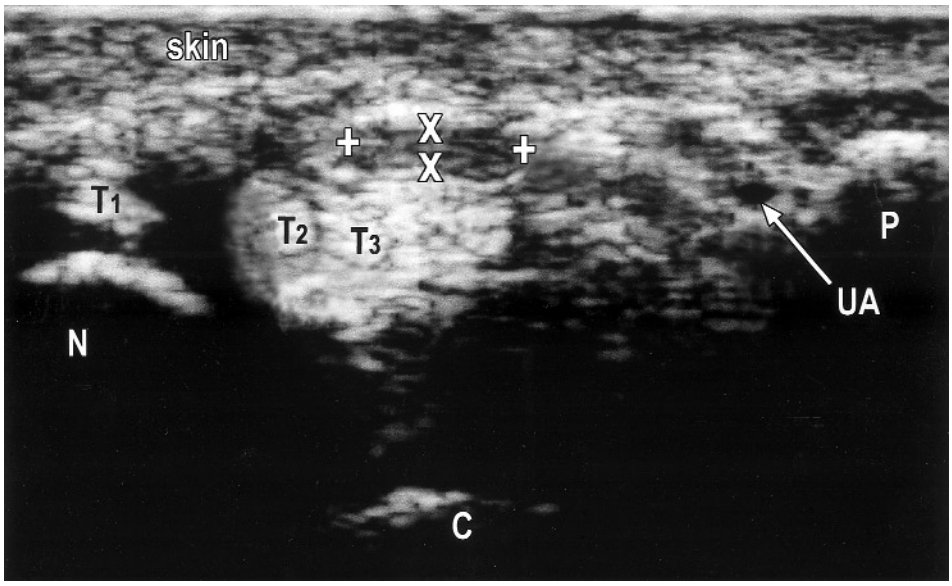

Figure 2. Transverse sonographic image of the entrance to the carpal tunnel with a normal median nerve.

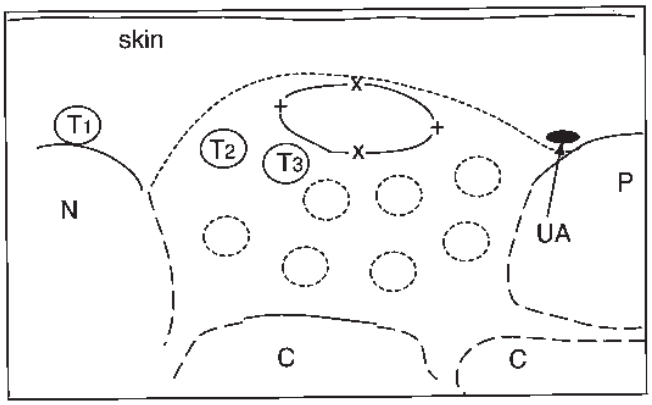

Figure 3. Transverse view of the entrance to the carpal tunnel with a swollen median nerve, indicating CTS. Symbols as in Figure 1.

latter 2 criteria are still a question of debate[22-24]. The former is at the entrance and the latter 2 criteria are at the exit of the carpal tunnel. On a transverse image, the median nerve usually has an elliptical shape. Swelling of the median nerve at the entrance to the carpal tunnel appears to be the most reliable criterion for diagnosing CTS[11,17,22,23,27,28]. The mean cross sectional area of the median nerve at the level of the entrance to the carpal tunnel between the pisiform bone and tubercle of navicular normally should not exceed 10 mm^2 [17,22,27,29]; otherwise it is swollen and diagnostic for CTS. This swelling is caused by edema.

Tanzer[25] and Rietze and Onne[26] reported that median nerve changes observed at surgery, especially swelling of the median nerve at the entrance to the carpal tunnel, were encountered in 43 and 66% of their patients, respectively.

We chose swelling of the median nerve at the entrance to the carpal tunnel as the SG criterion for CTS (Figures 2, 4). We measured height and width of the median nerve each 3 times with the transducer in the transverse position at the entrance to the carpal tunnel. The mean height (R1) and width (R2) were calculated.

For the mean cross sectional area in mm^2, the formula for an ellipse was used:

$$1/4 \times R1 \times R2 \times pi\ (= 3.14)$$

To find the most favorable cutoff point we used the ROC-curve (receiver operating characteristic curve), plotting the sensitivity versus 1 – specificity for different possible cutoff points of the mean cross sectional area.

During SG the patient sat in a chair with both forearms and the hands in horizontal-supine position on an examination couch.

Nerve conduction study

NCS was performed in the 6 weeks prior to surgery. The electromyograph used was the Nihon-Kohden, Neuropack 4. All NCS were performed by a trained technician. Based on the NCS the diagnosis of CTS was confirmed or rejected by an expert (FB), without knowledge of the clinical data and surgical results.

There are no uniform accepted international criteria for the diagnosis of CTS by NCS, and different cutoff points for individual criteria are found in literature. In this study an assessment of all NCS criteria defined below was used for the diagnosis of CTS.

Measurements[30] performed and cutoff points of normal values used in our study were as follows. (1) The median nerve distal sensory latency (DSL-2) of the index finger, upper limit of normal 3.6 ms. (2) The difference between the median and ulnar nerve distal sensory latencies of the fourth finger (ΔDSL-4), upper limit of normal 0.4 ms. (3) The distal motor latency (DML-1) over the thenar, upper limit of normal 4.3 ms. (4) The median motor nerve conduction velocity (mMCV), lower limit of normal 49 m/s. (5) The median sensory nerve conduction velocity (mSCV), lower limit of normal 49 m/s. (6) The ulnar motor and sensory nerve conduction velocities (uMCV and uSCV). Measurements 4, 5, and 6 were performed for the forearm.

The following criteria were used to confirm the diagnosis of CTS according to the NCS: increase in the median sensory distal latency of digit 2 (DSL-2) and/or digit 4 (ΔDSL-4) and/or an increase in the median motor distal latency (DML-1) with normal forearm conduction velocities (mMCV, mSCV, uMCV, and uSCV).

Further, the diagnostic value of the distal sensory latencies of the fourth finger (ΔDSL-4), criterion 2, as sole NCS criterion was tested.

Surgical procedure

Surgery was performed by one surgeon (JWD), under regional anesthesia with tourniquet control to minimize vascular bleeding. All operations were performed with an open technique using a longitudinal incision between the thenar and hypothenar eminences of roughly 3 cm in length without

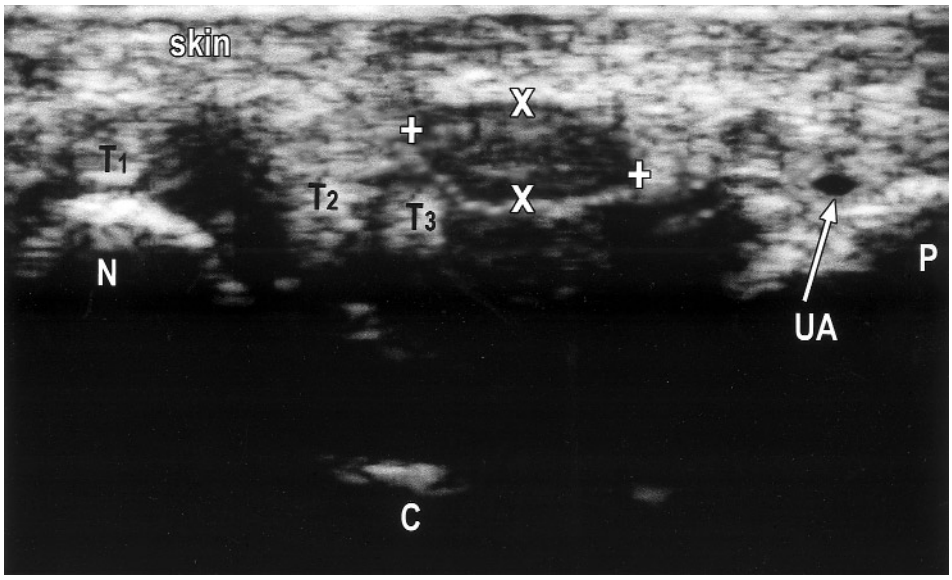

Figure 4. Transverse sonographic image of the entrance to the carpal tunnel with swollen median nerve, indicating CTS. Symbols as in Figure 1.

extension proximal to the wrist volar flexion crease. With this technique, the entire transverse carpal ligament can be transected under direct vision.

Statistics. For the 63 patients the clinical effect (relief of ≥ 90% of initial complaints) 3 months after surgery was considered to be the gold standard for the diagnosis of CTS. Sensitivity, specificity, positive and negative predictive values, and accuracy of SG and NCS for the presence of CTS were calculated, the 95% confidence limits being exact values, according to the binominal distribution. To compare the results of SG and NCS with regard to CTS, McNemar's tests were applied. Statistical analyses were performed with the Number Cruncher Statistical System version 97 (J.L. Hintze, Kaysville, UT, USA).

RESULTS

Two patients were excluded from the study because of signs of polyneuropathy on electromyography.

Of the 63 patients, 47 (75%) had relief of complaints (≥ 90%) after surgery. Different cutoff points were studied for the sonographic criterion by means of an ROC-curve. Cutoff points of 9.51, 10.0, and 11.18 mm^2 for the mean cross sectional area of the median nerve yielded a sensitivity of 0.77, 0.70, and 0.51 and a specificity of 0.50, 0.63, and 0.81, respectively. For our calculations, the cutoff point for a pathological mean cross sectional area of the median nerve of > 10 mm^2 was used. When SG was compared with the gold standard, 33 true positive and 10 true negative tests were counted, while 14 false negative and 6 false positive tests were scored. These results yielded a sensitivity of 0.70 (95% CI 0.55–0.83), specificity of 0.63 (95% CI 0.35–0.85), a positive predictive value (PPV) of 0.85 (95% CI 0.69–0.94), negative predictive value (NPV) of 0.42 (95% CI 0.22–0.63), and accuracy of 0.68 (95% CI 0.55–0.79) (Table 2).

The sonographic findings for our patients were compared to SG findings in 20 asymptomatic left wrists of 20 control patients. In the group of patients with CTS, the mean cross sectional area of the median nerve at the level of the pisiform bone was 11.3 mm^2 (range 6.2–21.2, SD 3.1 mm^2) compared to 6.1 mm^2 (range 3.4–9.6, SD 1.4 mm^2) for our control patients ($p < 0.0001$).

For the 63 patients, 46 NCS were scored true positive, while 3 true negative NCS were found. Further, 13 false positive and only one false negative NCS were encountered. Therefore the results of NCS for CTS yielded a sensitivity of 0.98 (95% CI 0.89–1.00), a specificity of 0.19 (95% CI 0.04–0.46), a PPV of 0.78 (95% CI 0.65–0.88), a NPV of

Table 2. Test results.

	True +	True –	False +	False –	Sensitivity	Specificity	PPV	NPV	Accuracy*
NCS	46	3	13	1	0.98	0.19	0.78	0.75	0.78
ΔDSL-4	45	3	13	2	0.96	0.19	0.78	0.60	0.76
SG	33	10	6	14	0.70	0.63	0.85	0.42	0.68

*Gold standard: ≥ 90% relief of symptoms 3 months after surgery. NCS: nerve conduction study (all criteria) by the blinded neurologist. ΔDSL-4: difference between the median and ulnar nerve distal sensory latencies of the fourth finger as sole NCS criterion. SG: sonography (mean cross sectional area) performed by the blinded rheumatologist. PPV: positive predictive value, NPV: negative predictive value.

0.75 (95% CI 0.19–0.99), and accuracy of 0.78 (95% CI 0.66–0.87) (Table 2).

When only the ΔDSL-4 criterion, as sole NCS criterion, was used, there were 45 true positive NCS, 3 true negative, 13 false positive, and only 2 false negative NCS. This results in a sensitivity of 0.96 and specificity 0.19, respectively. For patients with CTS, the PPV of this method was 0.78, the NPV 0.60, and the accuracy 0.76 (Table 2).

DISCUSSION

The diagnosis of CTS is based mainly on the patient's history and clinical findings[18,31]. The value of physical provocative tests, such as Tinel's or Phalen's tests, for CTS is controversial[32]. Confirmation of CTS is usually based on NCS[32]. However, false negative[18] and false positive[33] NCS results do occur.

Grundberg[18] found an 8% rate of false negatives for patients with clinically obvious CTS whose symptoms were relieved by median nerve release in the carpal tunnel. Redmond[33] reported changes in at least one electrodiagnostic test for CTS in 23 (46%) of 50 healthy subjects with no symptoms of CTS, indicating a low specificity of NCS. The accuracy of electrodiagnostic tests for diagnosis of CTS has been estimated to be 80–90%[31].

Imaging techniques were unimportant in the assessment of CTS until this decade. Many articles on SG and MRI for CTS have since been published. Current criteria for both MRI and SG are: swelling of the median nerve at the entrance to the carpal tunnel, and flattening of the median nerve and palmar bowing of the flexor retinaculum at the exit from the carpal tunnel. For MRI an additional criterion is increased signal intensity within the median nerve on T2 weighted images at the exit from the carpal tunnel in cases of CTS. Thickening of the flexor retinaculum and an increased height of the carpal tunnel, as measured from the apex of the flexor retinaculum convexity to the underlying carpal bone, are also mentioned in both MRI and SG literature[10,22,24]. Thus, criteria for MRI and SG have become similar, but are subject to discussion[24,34]. Further validation of appropriate sonographic measurements and criteria to diagnose median nerve entrapment at the wrist are needed.

The extra dimension of imaging techniques such as MRI and SG over electrodiagnostic studies of the median nerve makes possible visualization of the origin of CTS (e.g., RA tenosynovitis; cysts or a ganglion in the carpal tunnel)[10,35,36]. Furthermore, when CTS is excluded, SG may show the cause of hand pain, e.g., a cyst or ganglion[14].

Longstanding compression may damage the integrity of the median nerve, influencing surgical outcome. But even a short period of extensive compression of the median nerve may lead to muscle atrophy. However, clinical experience shows that surgery may decrease complaints in these cases. For example, in our study only one patient had symptoms for several years and signs of atrophy, but symptoms decreased by 70% after surgery.

In the literature there are no criteria for a fixed length of time for CTS to exclude such patients. Therefore we did not use duration of compression or muscle atrophy as exclusion criteria.

However, longstanding compression of the median nerve may lead to muscle atrophy without swelling of the median nerve on SG.

The role of glucocorticoid injections in idiopathic CTS is still a matter of debate[37,38]; however, when RA tenosynovitis is the cause of the CTS, an injection is effective[39,40]. Thus sonography performed at the rheumatology department represents an extension of the diagnostic arsenal.

When CTS due to inflammatory tenosynovitis or synovitis of the wrist joint is diagnosed by SG, the rheumatologist can inject steroid before referral to surgery.

Sonography. Our cutoff point of 10 mm^2 for the mean cross sectional area of the median nerve, found by means of a ROC-curve, corresponds with data in the literature[17,22,27]. Buchberger[17] studied 20 wrists of 18 patients (14 women and 4 men) with CTS and, in another study[11], 28 wrists of 14 asymptomatic subjects (9 women and 5 men). The mean cross sectional area of the median nerve at the level of the pisiform bone in symptomatic patients was 14.5 mm^2 (range 8.8–20.5, SD 3.8 mm^2) compared to 8.1 mm^2 (range 6.7–12.8, SD 1.3 mm^2) in asymptomatic subjects. Buchberger's values for the mean cross sectional area correspond well with our cutoff point of 10 mm^2. In their review article on CTS assessment with SG, Chen, *et al*[27] describe criteria such as those of Buchberger. They confirm that the normal mean cross sectional area of the median nerve at the proximal carpal tunnel should not be more than 10 mm^2, which is in accordance with our study.

Calleja Cancho, *et al*[16] investigated the mean cross sectional area of the median nerve at the proximal carpal tunnel in 16 healthy volunteers. The mean normal width and height were 6.0 and 2.0 mm, respectively, leading to a mean cross sectional area of 9.4 mm^2, which corresponds nicely with our cutoff point of 10 mm^2 as the upper limit for normal values.

Paradas, *et al*[28] described in an abstract 34 patients with CTS between mean cross sectional area of the median nerve visualized by SG at the entrance to the carpal tunnel and electrophysiological data on CTS.

Comparison of the mean cross sectional area of the median nerve in symptomatic and asymptomatic subjects in our study showed that increased mean cross sectional area (> 10 mm^2) of the nerve at the proximal carpal tunnel is a reliable criterion for CTS.

Duncan, *et al*[23] found that for SG the most predictive criterion to diagnose CTS is swelling of the median nerve; the cutoff point for the mean cross sectional area was found to be 9.0 mm^2. This corresponds with our findings. The flat-

tening ration did not seem valuable. The authors concluded that quantitative assessment of the median nerve is an accurate diagnostic test, with sensitivity of 0.82 and specificity of 0.97. However, unlike our study, they used NCS as the gold standard. Lee, *et al*[36] found a cutoff point for the mean cross sectional area of the median nerve at the entrance of the carpal tunnel of 15 mm^2, with a sensitivity of 0.88 and specificity of 0.96. In this study also NCS was used as the gold standard. The data provided do not enable us to recalculate sensitivity and specificity in their sample for a cutoff point of 10 mm^2. Criteria for mild, moderate, and severe abnormal NCS are not provided in their study. Further, in their study most patients with mild and even some with moderate abnormal NCS did not reach their own cutoff point of 15 mm^2.

In our study 2 patients with poor results after surgery had a clearly pathological mean cross sectional area of ≥ 17 mm^2. One of them, with diabetes mellitus and hypothyroidism, had complaints of CTS for several years. This patient showed thenar atrophy and paresis of the abductor pollicis breves and the opponens pollicis, with only 70% improvement of complaints after surgery. For the other patient, we cannot explain why the CTS, characterized by such a large mean cross sectional area, only improved by 60% 3 months after surgery.

In 6 cases the SG was false positive for CTS; the 6 NCS were also false positive for CTS. The SG of 14 patients was false negative for CTS. In 13 of these cases, the NCS appeared to be true positive for CTS; one patient had a false negative result on the NCS for CTS.

False negative results might be explained by the presence of CTS in patients with normal sizes of the mean cross sectional area of the median nerve on SG or inaccuracy of the measurements. In the present study, 30 of 63 patients (48%) had a mean cross sectional area between 10 and 15 mm^2, and they all had ≥ 90% relief of their complaints. In our opinion a mean cross sectional area of the median nerve of ≥ 10 mm^2 in CTS is a correct cutoff point.

Nerve conduction study. The score of the NCS for CTS using all criteria showed a high sensitivity and a low specificity, possibly because these patients were highly selected. After referral by the house physician, patients were seen by the neurologist and had a high prevalence of CTS. If NCS had been performed in a less selected population, sensitivity would have been lower and specificity higher. Another explanation for the low specificity might be an intrinsic problem of NCS, resulting in a high rate of false positive results, as found in different studies[33,41].

In case ΔDSL-4 was used as the sole NCS criterion, the same high sensitivity and the same low specificity were scored compared to the NCS using all criteria for CTS (Table 2). A significant number of true positive tests, 45 out of 63 tests (71%), was obtained using only the ΔDSL-4 criterion, while the NCS using all criteria yielded 46 out of 63 tests (73%). This illustrates that assessment of the ΔDSL-4 as sole NCS criterion is a sensitive method for detection of CTS, which is in accordance with the literature[42-47].

Thirteen patients had a false positive NCS. In these cases, SG showed no CTS in 7 cases correctly, while 6 of these patients had a false positive SG as well.

In mild CTS, distal sensory latency is considered a more useful early discriminant compared to distal motor latency; about 85 to 95% of patients with clinical signs of CTS have a delayed sensory response. In contrast, usually occurring in a later phase of CTS, the distal motor latency shows prolongation and occurs in 66 to 84% in mild CTS. Severe CTS will cause prolongation of motor latency on the NCS in an early stage and a tendency toward atrophy of the muscle[48,49].

Testing of only the ΔDSL-4 along the ring finger was diagnostic for about 28 (74%) of 38 patients with clinical CTS[47]. These results are in agreement with our findings. Gunnarsson, *et al*[50] reported among 100 subjects with clinical signs and symptoms of CTS a sensitivity of 0.85 and specificity of 0.87 for the neurophysiological examinations. In that study, the gold standard was based on (1) drawings made by the patient of the affected fingers on a hand diagram, (2) neurophysiological results, (3) relief of CTS symptoms after surgery, and (4) findings at surgery. With regard to our overall NCS sensitivity (0.98), there seems to be agreement. Our NCS specificity (0.19) does not correspond with their data, but this can be explained by our study protocol, in which selection for the study was made by the neurologist. In their study, the inclusion criterion was referral by the general practitioner who suspected CTS. An estimated 15% of the patients with classic clinical symptoms of CTS are not identified by NCS[51]. Moreover, in the general population, individuals who have no symptoms may have pathological median nerve studies[33].

It seems reasonable to suggest that SG can be used to determine the possible origin of CTS, such as tenosynovitis or wrist-joint arthritis.

In conclusion, SG is a cheap, easy, pain-free, rapid imaging technique. Using the mean cross sectional area of the median nerve as the diagnostic criterion, CTS can be diagnosed by SG. SG has good sensitivity and should be considered another valuable tool in managing CTS.

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