PRESSURES IN THE CARPAL TUNNEL

A COMPARISON BETWEEN PATIENTS WITH CARPAL TUNNEL SYNDROME AND NORMAL SUBJECTS

S. ROJVIROJ, W. SIRICHATIVAPEE, W. KOWSUWON, J. WONGWIWATTANANON,
N. TAMNANTHONG, P. JEERAVIPOOLVARN

From Khon Kaen University, Thailand

We studied pressure in the carpal tunnel in patients with carpal tunnel syndrome and in normal control subjects, using a slit catheter and recording in the neutral position, 90° dorsiflexion, and 90° palmarflexion of the wrist.

For each position the mean pressure in the patients was very significantly higher than in the controls, the highest pressure being in 90° dorsiflexion, and the lowest in the neutral position. Using an upper limit of normal pressure of 5.5 mmHg in the neutral position gave a diagnostic sensitivity of 78.7%, a specificity of 78.1%, an accuracy of 78.5%, and a positive predictive value of 87.3%.

There are several possible causes of carpal tunnel syndrome but most cases are idiopathic. Increased pressure due to fluid or the presence of anomalous structures may be associated (Butler and Bigley 1971; Eriksen 1973) and a reduction in the cross-sectional area of the tunnel may be found in patients with the syndrome (Dekel et al 1980; Liang 1987).

The pressure in the carpal tunnel has been measured by wick catheter in patients and normal subjects by Gelberman et al (1981), but nearly one-third of their patients did not have the idiopathic syndrome and results were not given in terms of sensitivity, specificity or predictive value. We have compared pressures in fully-documented normal subjects and in patients with idiopathic carpal tunnel syndrome, then calculated their diagnostic value.

PATIENTS AND METHODS

We studied 33 patients, 25 female and 8 male, in whom 61 hands were affected by carpal tunnel syndrome. Their ages ranged from 19 to 67 years (mean 46.5) and the duration of symptoms was one month to 10 years, (mean 19 months). All patients had paraesthesia or numbness in the distribution of the median nerve, and the diagnosis of carpal tunnel syndrome was made on the physical signs, the wrist flexion test (Phalen 1972), and the median nerve percussion test (Tinel 1915; Mossman and Blau 1987), then confirmed by electrodiagnostic studies. These showed the affected median nerve to have a prolonged distal sensory latency (more than 3.5 msec), or a distal motor latency of more than 4.5 msec, or both (Kimura 1983). Electromyograms of the abductor pollicis brevis were abnormal in 11 hands, and three had wasting of the thenar muscles.

The 12 male and four female control subjects had 32 normal hands with no history of trauma or abnormality about the wrist and normal results on electrodiagnostic testing of their median nerves.

Pressure tests. The slit catheter is a 20 cm length of polyethylene tubing 1.2 mm in diameter, with five symmetrical slits each extending 3 mm from its end. This catheter is connected by tubing to a transducer dome, to which is also attached a stopcock with a 20 ml syringe filled with sterile water. Air bubbles are excluded from the system, and the tip of the connecting tube, the transducer and the carpal tunnel are placed at the same

---

S. Rojviroj, MD, Assistant Professor
W. Sirichativapee, MD, Instructor
W. Kowsuwon, MD, Assistant Professor
J. Wongwiwattananon, MD, Instructor
N. Tamnanthong, MD, Assistant Professor
P. Jeeravipoolvarn, MD, Associate Professor
Department of Orthopaedics and Rehabilitation Medicine, Srinagarind Hospital, Faculty of Medicine, Khon Kaen University, Khon Kaen 40002, Thailand.

Correspondence should be sent to Dr S. Rojviroj.

© 1990 British Editorial Society of Bone and Joint Surgery
0301-620X/90/3087 \$2.00
J Bone Joint Surg [Br] 1990; 72-B: 516-8.

horizontal level while the system is adjusted until the monitor records zero pressure. The connecting tube is then elevated to 54 cm and the range control adjusted to 40 mmHg. The system is then calibrated and ready for use (Fig. 1).

Under local anaesthesia, a 14 gauge needle with a plastic sheath is inserted at 45° 1 cm proximal to the distal wrist crease, on the ulnar side of the palmaris longus tendon, and pushed in to the carpal tunnel. The needle is withdrawn leaving the plastic sheath within the tunnel. The slit catheter is then inserted through the plastic sheath until resistance is felt, when the plastic sheath is withdrawn. The response of the system is checked by pressing a fingertip over the carpal tunnel and observing the response on the monitor. In two clinical cases regional anaesthesia was used, the catheters were left in place during the operation, and the correct location of the tips within the carpal tunnel was proved.

Measurements of carpal tunnel pressures were made with the wrist placed passively in neutral position, in 90° palmar flexion, and in 90° dorsiflexion. Mean pressures, standard deviations and standard errors were calculated, and analysed by Student's *t*-test. The diagnostic value of the test was calculated in terms of sensitivity, specificity, accuracy and predictive value.

RESULTS

The carpal tunnel pressures are shown in Table I. In both patients and controls the mean pressure was lowest in the neutral position and highest in 90° dorsiflexion. In all three positions there were very highly significant differences between the mean pressures in the patients compared with the control subjects. For the neutral position $p < 0.0002$, and the significances of the differences were even greater in dorsiflexion and palmarflexion. We found no statistically significant difference between the left and right hands of the control subjects ($p > 0.4$) but again the pressure was very significantly higher in dorsiflexion than in palmarflexion, and in palmarflexion than in the neutral position.

We chose 5.5 mmHg as the upper limit for normal carpal tunnel pressure in the neutral position. This gave a sensitivity of 78.7%, a specificity of 78.1%, and a diagnostic accuracy of 78.5%. The positive predictive value of the test was 87.3%.

DISCUSSION

Pressure in the carpal tunnel has been measured in several ways. Tanzer (1959) introduced a mercury bag and showed that pressure was increased by flexion or extension of the wrist. Our study showed that the mean pressure is greatest at 90° dorsiflexion. Brain, Wright and Wilkinson (1947), studying cadavers, also found that wrist dorsiflexion caused a greater increase than palmarflexion.

Gelberman et al (1981), using a wick catheter, found that the mean pressure in the carpal tunnel was elevated in patients with carpal tunnel syndrome. We used a slit catheter system; this has been shown to be as accurate as a wick catheter (Rorabeck et al 1981). Our results differ from those of Gelberman et al, in that our mean carpal tunnel pressures were lower, especially in our patient group (Table II): only one of our patients had a pressure

Table I. Mean carpal tunnel pressure $\pm$ s.e.m. in various positions of the wrist

Position of wrist	Mean pressure in mmHg	
	Carpal tunnel syndrome (n = 61)	Normal (n = 32)
Neutral	11.87 $\pm$ 1.53	3.48 $\pm$ 0.43
90° palmarflexion	26.60 $\pm$ 2.53	9.32 $\pm$ 1.06
90° dorsiflexion	32.76 $\pm$ 3.21	12.68 $\pm$ 1.16

Table II. Mean carpal tunnel pressure $\pm$ s.e.m. (range) in various wrist positions in two series of patients with carpal tunnel syndrome

Position of wrist	Mean pressure in mmHg	
	Gelberman et al 1981 (n = 15)	Rojviroj et al 1990 (n = 61)
Neutral	32 $\pm$ 0.98 (2 to 50)	11.87 $\pm$ 1.53 (1.5 to 62.2)
90° palmarflexion	94 $\pm$ 5.18 (20 to 250)	26.60 $\pm$ 2.56 (5 to 81.8)
90° dorsiflexion	110 $\pm$ 5.68 (15 to 250)	32.78 $\pm$ 3.21 (4 to 111.2)

Fig. 1

Diagram of apparatus.

Table III. Mean carpal tunnel pressure $\pm$ s.e.m. (range) in various wrist positions in two series of normal subjects

Position of wrist	Mean pressure in mmHg	
	Gelberman et al 1981 (n = 12)	Rojviroj et al 1990 (n = 32)
Neutral	2.5 $\pm$ 0.17 (0 to 7)	3.48 $\pm$ 0.43 (0 to 8.6)
90° palmarflexion	31.0 $\pm$ 0.86 (15 to 75)	9.54 $\pm$ 1.06 (2 to 28.5)
90° dorsiflexion	30.0 $\pm$ 1.24 (4 to 50)	12.46 $\pm$ 1.16 (3.2 to 27.4)

of more than 100 mm/Hg. This may be because all our cases were idiopathic in origin. In our control subjects, all confirmed by normal electrodiagnostic studies, we also found lower mean pressures (Table III).

The wrist flexion or Phalen test has been claimed to

be the most sensitive diagnostic test (Gelman et al 1986). Our finding that the mean pressure was highest in 90° of dorsiflexion, implies that provocative testing for carpal tunnel syndrome by wrist extension may be at least as sensitive as wrist flexion.

Conclusions. The pressure in the carpal tunnel of patients with an idiopathic carpal tunnel syndrome, was very significantly higher than normal. In both patients and control subjects, the mean pressure was highest in 90° of wrist dorsiflexion, and lowest in the neutral position. Using our slit catheter method, a pressure of more than 5.5 mmHg in the neutral position had a positive predictive value of 87.3% for carpal tunnel syndrome.

No benefits in any form have been received or will be received from a commercial party related directly or indirectly to the subject of this article.

REFERENCES

- Brain WR, Wright AD, Wilkinson M. Spontaneous compression of both median nerves in the carpal tunnel: six cases treated surgically. *Lancet* 1947; i:277-82.
- Butler B Jr, Bigley EC Jr. Aberrant index (first) lumbrical tendinous origin associated with carpal-tunnel syndrome: a case report. *J Bone Joint Surg [Am]* 1971; 53-A:160-2.
- Dekel S, Papaioannou T, Rushworth G, Coates R. Idiopathic carpal tunnel syndrome caused by carpal stenosis. *Br Med J* 1980; 280:1297-9.
- Eriksen J. A case of carpal tunnel syndrome on the basis of an abnormally long lumbrical muscle. *Acta Orthop Scand* 1973; 44:275-7.
- Gelberman RH, Hergenoeder PT, Hargens AR, Lundborg GN, Akeson WH. The carpal tunnel syndrome: a study of carpal canal pressure. *J Bone Joint Surg [Am]* 1981; 63-A:380-3.
- Gelman H, Gelberman RH, Tan AM, Botte MJ. Carpal tunnel syndrome. *J Bone Joint Surg [Am]* 1986; 68-A:735-7.
- Kimura J. *Electrodiagnosis in diseases of nerve and muscle: principles and practice*. Philadelphia, FA Davis Company, 1983.
- Liang C-L. CT-scanning study of cross-sectional area of the carpal tunnel in cases of carpal tunnel syndrome. *Nippon Seikeigeka Gakkai Zasshi* 1987; 61:1033-44.
- Mossman SS, Blau JN. Tinel's sign and the carpal tunnel syndrome. *Br Med J* 1987; 294:680.
- Phalen GS. The carpal tunnel syndrome: clinical evaluation of 598 hands. *Clin Orthop* 1972; 83:29-40.
- Rorabeck CH, Castle GSP, Hardie R, Logan J. Compartmental pressure measurements: an experimental investigation using the Slit catheter. *J Trauma* 1981; 21:446-9.
- Tanzer RC. The carpal-tunnel syndrome: a clinical and anatomical study. *J Bone Joint Surg [Am]* 1959; 41-A:626-34.
- Tinel J. Le signe du frouillement dans lésions des nerfs périphériques. *Presse Méd Par* 1915; 23:385-9.