THE CARPAL TUNNEL SYNDROME

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In recent years the carpal-tunnel syndrome has been established as a definite clinical entity. In 1947 Brain *et al.*[1] described 6 cases and in 1953 Kremer *et al.*[2] reported 40 cases. These outstanding papers clarified the clinical picture and described the surgical treatment required to obtain relief from the distressing symptoms.

In this paper a further 13 patients in whom 19 median nerves were involved are described. These include 2 Cape Coloured females and 1 European male. Of the 19 median nerves 16 were decompressed by operation.

DESCRIPTION

Sex. The syndrome occurs predominantly amongst women. In this series, 12 of the 13 patients were women. Kremer *et al.*[2] report 5 times as many women as men affected, and all 6 patients in the paper by Brain *et al.*[1] were women.

Age. It is middle-aged persons who are most commonly affected. The ages in this series of 13 patients range from 42 years to 65 years with 8 patients in the 5th decade, and 4 in the 4th.

Symptomatology

Characteristically there are paraesthesiae, numbness and pain or ache in the median-nerve distribution in the hand. However, the most important clinical feature is the paroxysmal nocturnal nature of the attack. All the patients, except one (case 4), stated quite unequivocally that their symptoms were far worse at night, the vast majority having lost not less than 2 hours of sleep every night. The symptoms were usually aggravated by manual work performed during the day. All the patients tried to relieve the symptoms by shaking or rubbing, or hanging their hands over the edge of the bed, but in most instances little or no relief was obtained by these manoeuvres. Of the 13 patients, 7 experienced a feeling of 'swelling' or 'bursting' in the affected fingers at night, but no actual swelling was ever detected by them.

Despite the fact that it is the area of distribution of the median nerve that is usually involved, all the fingers were affected in 6 patients. It is probable that this additional involvement of the area of distribution of the ulnar nerve may be explained by the observation that occasionally branches of the ulnar nerve carrying sensory or motor fibres, and given off high in the forearm, join the median nerve. This has been confirmed at operations for severed ulnar and median nerves which present with apparently anomalous clinical pictures.

This condition has also been noticed to occur during pregnancy. In this series case 3 presented when she was 7 months pregnant. The severity of her symptoms necessitated an operation and the changes found at the operation were the same as those observed in other patients on whom the operation was performed.

Signs

(*a*) *Sensory* signs may take the form of hypo- or hyperaesthesia in one or more of the affected digits, but rarely in all. Generally, the sensory signs, when present, are discouragingly vague. In 9 patients sensory changes were found.

(*b*) There were only 4 patients with signs of *motor* disturbance. In 3 there was slight wasting of the abductor

TABLE I. DETAILS OF CASES

No.	Name, Age (yrs.) and Race	Duration	Handedness	Unilateral or Bilateral	Paraesthesiae	Numbness	Pain or Ache	Sensory Changes	Motor Changes	Flexion Test	Tinel's Test	Operation	Result
1	Miss E.W. 55. Eur.	5½ yrs.	Right	Left	+	+	+	0	Slight wasting of APB	Not recorded	Negative	Yes	Excellent
2	Mrs. J.S. 55. Eur.	5 yrs.	Right	Bilateral	0	+	+	0	Slight wasting of APB	Not recorded	Negative	Yes (Right)	Excellent
3	Mrs. C.R.G. 40. Eur.	2 mths.	Right	Right	+	+	+	0	Slight weakness of OP	Not recorded	Positive 40 secs. III finger	Yes	Excellent
4	Mr. C.G. 50. Eur.	6 mths.	Right	Left	+	+	0	+	0	Positive 40 secs. III finger	Positive III finger	Yes	Excellent
5	Mrs. W.C. de W. 57. Eur.	3 yrs. 1 mth.	Right	Left Right (L>R)	+ 0	+ +	+ 0	+ +	0 0	Positive 45 secs. II & III fingers. Positive 40 secs. II & III fingers	Positive Positive II & III fingers	Yes No	Excellent
6	Mrs. D. M. de W. 45. Eur.	4 mths.	Right	Right	+	0	0	+	0	Positive 50 secs. III finger	Positive III finger	Yes	Excellent
7	Mrs. H.A.T. 42. Eur.	6 mths.	Right	Bilateral	+	0	+	+	0	Not recorded	Not recorded	Yes (Left)	Excellent
8	Mrs. F.M. 52. Eur.	1 yr.	Right	Bilateral (L>R)	0	+	0	0	0	Positive 1 min. 20 secs. III finger	Negative	Yes Yes	Excellent
9	Mrs. G.R. 44. Eur.	8 yrs.	Right	Right	+	+	+	0	0	Positive 40 secs. II & III fingers	Negative	Yes	Excellent
10	Miss J.R.R. 50. Eur.	3 mths.	Right	Bilateral (L>R)	+	+	0	0	0	Positive 50 secs. II, III & radial half IV finger	Negative	Yes Yes	Excellent
11	Mrs. T.D. 65. Col.	1 mth.	Right	Right	+	0	+	+	0	Positive 40 secs. III finger	Negative	Yes	Excellent
12	Mrs. M.L. 53. Col.	1 mth.	Right	Right	+	+	+	+	0	Positive 40 secs. III finger	Positive III finger	Yes	Excellent
13	Mrs. L.R.F. 55. Eur.	4 yrs.	Right	Bilateral	+	+	0	+	Wasting of APB R & L	Positive 40 secs. II & III fingers	Negative	Yes Yes	Excellent

Eur.=European. Col.=Coloured. +=present. 0=absent. APB=abductor pollicis brevis. OP=opponens pollicis. R=right. L=Left. II, III, IV=Index, middle and ringfingers respectively.

Fig. 1. Incision for decompression of the median nerve.

Fig. 2. Median nerve exposed after division of the flexor retinaculum.

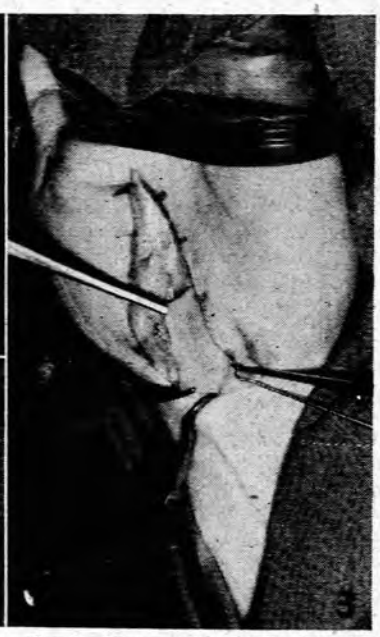

Fig. 3. Non-specific thickening of sheath surrounding flexor tendons.

pollicis brevis and in 1 there was some weakness of the opponens pollicis. This is not in accord with the findings of Kremer *et al.*[2]: their paper records motor changes in 22 of 40 patients. The presence of the motor signs appears to have a direct relationship with the duration of the condition (cases 1, 2, 13), but there is no corresponding association with the sensory changes.

Diagnostic Tests

Tourniquet test. This test was first described by Gilliatt and Wilson.[3] Owing to its time-consuming nature and the difficulty of accurate interpretation it was not employed in this series.

Tinel's test. This involves tapping and compressing the median nerve at the proximal border of the flexor retinaculum with the examiner's index finger. It was negative in 7 of the 12 patients in whom it was attempted. When the test was positive, it was found that the numbness or paraethesiae was always felt by the patient in the middle finger.

Flexion test. The patient's wrists are flexed actively to 90° (palmar flexion) and this position is maintained for not less than 40 seconds. In every case where it was recorded in this series (9 patients) it was positive, that is to say, the patients experienced paraesthesiae or numbness in the middle finger and occasionally in adjacent fingers as well.

Differential Diagnosis

This is usually easy. The conditions to be considered are *inter alia* motor neurone disease, syringomyelia and the far more commonly occurring cervical spondylosis and cervical disc lesions. The diagnosis is essentially established clinically. Therefore the discovery of disc degeneration or foraminal irregularity in the radiographs should not influence one unduly, because these features are commonly seen in middle-aged patients who are entirely free from symptoms.

TREATMENT

Rest

Walshe[4] advocates rest. In this series rest was advised when patients refused operation at first. Transient improvement occurs, but the symptoms always recur on resumption of former activity or after discarding their plaster casts or splints.

Hydrocortone Injections

This treatment has been advised by some authorities. In view of the pathological anatomy found at operation the procedure seemed illogical and it was not attempted in this series.

Operation

Complete division of the flexor retinaculum (anterior carpal ligament) affords immediate and lasting relief from the distressing symptoms. The division must be complete to obtain a successful result (Kremer *et al.*[2]).

In my opinion the procedure advised by Kremer *et al.* carries with it certain elements of danger. These authors prefer a blind division of the flexor retinaculum through a short transverse incision in the distal wrist crease. Sometimes the palmar cutaneous branch of the median nerve lies in front of the flexor retinaculum and this might be damaged by blind 'division'. Furthermore, blind division may be incomplete. It is a safer and more accurate operation to expose the whole of the flexor retinaculum and to divide it under direct vision.

Pre-operative preparation. The day before the operation the whole upper limb from the axilla downwards is shaved and thoroughly washed with soap and water and enclosed in sterile towels. This preparation is quite sufficient.

Anaesthetic. A general anaesthetic is usually employed but a brachial-plexus block would also be suitable where it is indicated.

Tourniquet. The limb is exsanguinated with an Esmarch bandage, and the pneumatic cuff, placed round the upper arm, is pumped up to 240-260 mm. Hg. After towelling, a sterile rubber glove is used to cover the distal portion of the palm and fingers so as to leave the thumb free.

Incision. The incision skirts the base of the thenar eminence and stops proximally at the crease of the wrist (Fig. 1). The incision is then deepened and the skin is dissected free for a distance of ½ inch on either side, thereby exposing the flexor retinaculum. At the proximal end of the incision the median nerve is seen either projecting medial to flexor carpi radialis or between the latter and the palmaris longus, when present. The colour and the usually thread-like median artery on the anterior aspect of the nerve makes its recognition easy (Fig. 2). The nerve is gently retracted radially with a blunt nerve hook. The flexor retinaculum, which is a surprisingly tough and thick structure proximally, is divided completely proximo-distally. The skin is then sutured with interrupted 3/0 linen or silk thread. The operative procedure takes approximately 10 minutes.

A pressure bandage is applied and the tourniquet released. The limb is kept elevated for 48 hours and finger, elbow and shoulder movements are commenced immediately. On the 10th day the sutures are removed. The scar becomes practically invisible in 6-8 weeks.

Observations at Operations

1. *The flexor retinaculum* was thicker than normal at its proximal end in some instances. However, no method has been devised to confirm this impression by measurement.

2. *The covering of the nerve* was found to be thickened, glistening and latex-like.

3. *The median nerve* was slightly narrowed at the proximal border of the flexor retinaculum in 5 instances. In no case was the nerve found swollen proximal to the proximal border of the flexor retinaculum. This is contrary to what Dall[5] describes, although in his paper no cases are analysed. The colour changes in the nerve described by Brain *et al.*[1] in their series were also not observed.

4. *The flexor tendons.* A striking feature in every instance was the abnormally thick, off-white, 'stretchy' sheath of the flexor tendons, which extended 1 inch proximal to the proximal border of the flexor retinaculum (Fig. 3). In case 1, where this thickened sheath was incised, a colourless, watery fluid exuded. This feature was not found in the other cases. In cases 3 and 5 a tendon was completely stripped and the material was sectioned. The histological structure in both instances is described as 'non-specific' thickening. This feature is referred to below.

Results of Operation

All the patients except one experienced dramatic symptomatic relief from the first post-operative night. This relief is permanent. The exception is case 9, in whom the symptoms

had been present for 8 years; this patient was only partially relieved on the first post-operative night, but was completely symptom-free 24 days after the operation.

DISCUSSION

The carpal tunnel is a fibro-osseous canal formed by the natural concavity of the anterior aspect of the carpus (Fig. 4) and bounded by the broad, strong fibrous flexor retinaculum. The canal permits passage of the tendons of the flexor digitorum sublimis and profundus, the tendon of the flexor

Fig. 4. Osseous boundaries of entrance to carpal tunnel.

pollicis longus, and the median nerve. These structures are firmly packed in the tunnel, separated from each other only by the tendon sheaths (Fig. 5), and proximally the median nerve lies between the border of the flexor retinaculum anteriorly and the radial bursa posteriorly.

The flexor retinaculum presents a number of features of practical importance, some of which have not been previously described. Proximally it is continuous with the deep fascia of the forearm, but on the ulnar side it also receives an expansion from the tendon of the flexor carpi ulnaris while, centrally, the deep aspect of the palmaris longus is attached

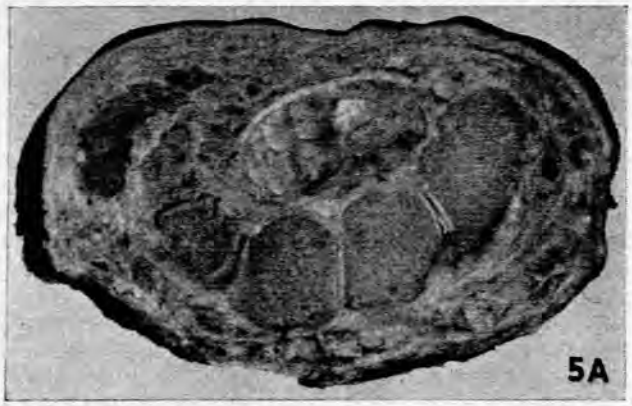

Fig. 5 (*a*). Section through the carpal tunnel to illustrate the extent of flexor retinaculum and the 'tight fit' of the structures passing through the carpal tunnel.

to it in a broad expansion. This fact is important because it means that in this region the median nerve is protected by a thick fibrous covering about 2 mm. thick, which has to be cut through at operation and which acts as a compressional 'bar' if the median nerve is pushed against it anteriorly by the swelling of the tendon sheaths behind. This might explain the narrowing of the nerve found at operation in the 5 instances recorded (Table I). Distally

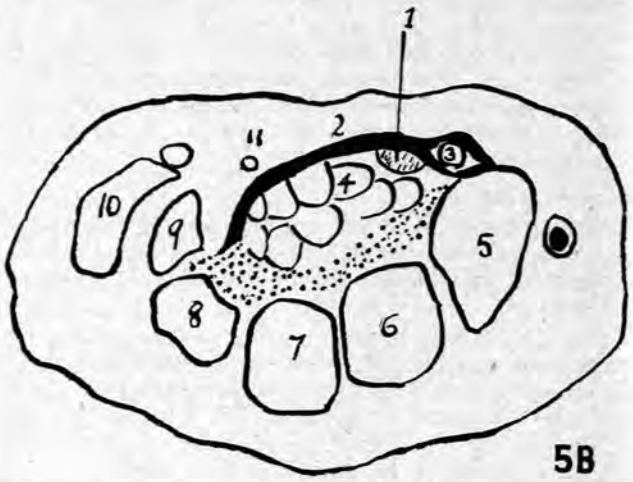

Fig. 5 (*b*). Line drawing of Fig. 5 (*a*). 1=median nerve. 2=flexor retinaculum. Stippled area indicates extensions of retinaculum blending with intercarpal ligaments and periosteum. 3=flexor carpi radialis. 4=flexor tendons. 5=carpal navicular. 6=capitate. 7=lunate. 8=triquetrum. 9=pisiform. 10=hypothenar muscles. 11=ulnar vessels and nerve.

the flexor retinaculum imperceptibly blends with the thick palmar aponeurosis. Although the retinaculum is attached to the bony pillars of the tunnel laterally (tubercles of scaphoid and trapezium) and medially (a ridge on pisiform and the hook of hamate), it provides a firm, fibrous and wide source of origin for the hypothenar and thenar muscles, and in these regions the retinaculum is again found to be thickened and expanded. This is observed particularly on the radial side, where a deep slip of the retinaculum not only is attached to the lip of the groove below the ridge of the trapezium, thus forming a small canal for the tendon of the flexor carpi radialis, but also blends with the intercarpal interosseous ligaments. Furthermore, from all these bony attachments and passing on the inside of the bony pillars are fibrous strands of the retinaculum which blend with the relatively thick interosseous and transverse carpal ligaments. Consequently, on section (Fig. 5) the contents of the carpal tunnel are seen to be bound together by a strong fibrous tube ('sheath') firmly attached and wedged against the concave bony walls on the sides and posteriorly. Because of its powerful attachments and because it actually is the most effective factor in maintaining the carpal bony concavity, the flexor retinaculum tends to form a relatively unyielding strap anteriorly.

Compression within the tunnel would easily occur if the contents increased in bulk or if the tunnel became narrowed. The structure most sensitive to pressure is the median nerve. Arthritic changes in the carpus or excessive callus after fractures or mal-union could cause narrowing of the tunnel. These features were not present in this series. Increased thickness of the flexor retinaculum would produce the same effect. The operative findings were suggestive of this in some instances, but the impressions were not verified by objective methods.

In every instance, however, the tendons were covered by an abnormally thick sheath of material, the nature of which is not known. If all the tendons were stripped the material

would be of an appreciable bulk, sufficient to have increased the tension within the tunnel considerably and thus affect the conductivity of the nerve, either directly by pressure or indirectly by producing ischaemia.

CONCLUSIONS

It is suggested that the peritendinous thickening is an important causative factor in producing this syndrome. The cause and nature of the thickening remains unknown. The occurrence in middle-aged women and the striking nocturnal severity of the symptoms remain unexplained.

SUMMARY

1. 13 patients with 19 carpal tunnel compressions are described.

2. 16 median nerves were decompressed, with immediate permanent relief of symptoms.

3. It is suggested that the abnormally thickened peritendinous tissue constantly found at operations is an important cause of increased pressure within the carpal tunnel.

4. The flexion test was found to be the most constant positive diagnostic test.

I have very much pleasure in recording my thanks to my brother, Mr. Alec Singer, for his encouragement and valuable criticism and his kind permission to include cases 1, 2 and 9 in the series. I am most grateful to my brother, Dr. Ronald Singer, for the section on the anatomy of the carpal tunnel. My thanks are also due to Mr. B. V. Todt, who is responsible for the clinical photographs, and to Mr. G. McManus, who photographed the anatomical sections.

REFERENCES

1. Brain, W. R., Wright, A. D. and Wilkinson, M. (1947): Lancet, 1, 277.
2. Kremer, M., Gilliatt, R. W., Golding, J. S. R. and Wilson, T. G. (1953): *Ibid.*, 2, 590.
3. Gilliatt, R. W. and Wilson, T. G. (1953): *Ibid.*, 2, 595.
4. Walshe, F. M. R. in Feiling, A. (1951): *Modern Trends in Neurology*. London: Butterworth.
5. Dall, G. (1958): S. Afr. Med. J., 32, 758.

ADDENDUM

Since the completion of this paper the two following cases have presented:

A European woman, aged 55 years, with symptoms of 3 years' duration in her right hand. An operation has been performed, with complete relief of symptoms.

A European woman aged 23 years, who developed a typical carpal-tunnel syndrome 5 weeks *after* parturition. An operation has been performed on both hands, with immediate relief of symptoms. This case is of interest because of her age (by far the youngest in the series) and because the condition manifested itself after the end of pregnancy.