

THE ASSESSMENT OF HAND FUNCTION AFTER PERIPHERAL NERVE INJURIES

RUTH E. M. BOWDEN and J. R. NAPIER, LONDON, ENGLAND

From the Royal Free Hospital School of Medicine, London

The diagnosis, follow-up and final assessment of a peripheral nerve injury includes a detailed examination of the range of movement of individual joints, the power of individual muscles and the recovery of the various modalities of sensibility. Objective methods of examination and recording of results of such observations have been described by Seddon (1949). A numerical assessment of motor and sensory recovery suggested by Highet in an unpublished memorandum to the Nerve Injuries Committee of the Medical Research Council has proved of great value. Using this scheme, Zachary (1954) was able to analyse the functional

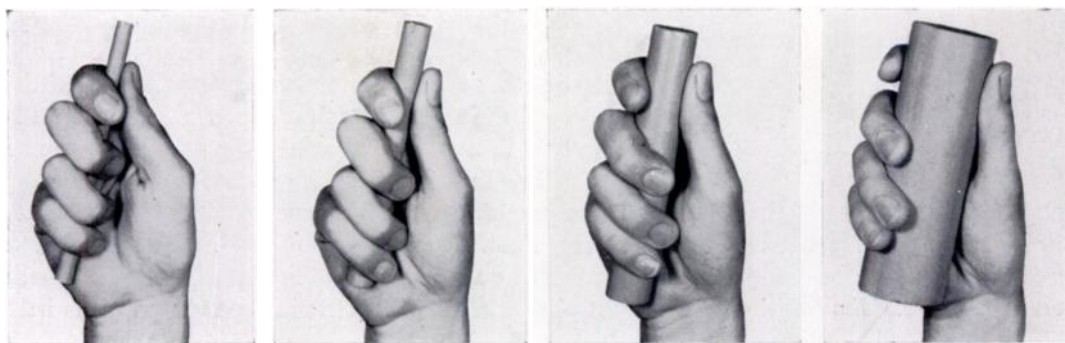


FIG. 1

Power grip; note the variation in posture of the wrist and digits with cylinders of different diameters.

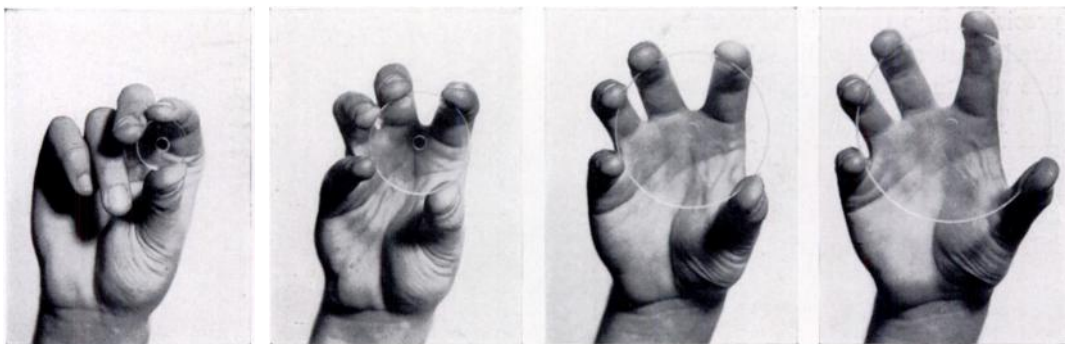


FIG. 2

Precision grip; note the variation in posture of the wrist and digits with Perspex discs of different diameters.

effects of delay in repair and of the level and length of lesions in different nerves. Valuable as these methods of recording results have proved, they are, to some extent, arbitrary and artificial in terms of everyday use of injured limbs. Whilst it is possible to make an indirect assessment of functional recovery on the basis of such data, this requires considerable experience and judgment (Davies 1949). There is clearly a need for a series of simple, repeatable tests of the function of the hand as a whole by which the patient's capabilities may be assessed directly. Want of such tests forces the examiner to place too much weight on the patient's own valuation



FIG. 3
Power and precision grip combined in a single posture

and a reinforcement of the clamp. In the *precision grip* the object is pinched between the flexor surfaces of the fingers and the opposing thumb (Fig. 2). The terms, like those of flexion and extension, can be used in a dynamic as well as a static sense to describe both a movement and a posture. The position of the wrist plays a significant part; in a power grip it is held either in neutral position or in very slight dorsiflexion, the degree of ulnar deviation increasing with the size of the object held (Fig. 1); in a precision grip the wrist is markedly dorsiflexed and the thumb lies in line with the radius (Fig. 4).

The purpose of this paper is to record results of a series of tests for power and precision grip in a group of patients with peripheral nerve injuries affecting the hand.

CLINICAL MATERIAL

One hundred and fifty-four patients were examined: 152 were men and two women and their ages at the time of injury ranged from seventeen to forty years. With two exceptions all have been treated in one of the special centres set up for the care of peripheral nerve injuries during the war and all were subsequently followed up by both of us from 1947 to 1954 at a clinic instituted at the request of the Medical Research Council, at the Royal Free Hospital, Lawn Road. Full records from the time of injury were available for all patients.

The grouping of the patients accords with the nerve affected; a summary of these groups is shown in Table I.

of his disability, an estimate which is an indispensable part of the history but is seldom dispassionate; the enterprising and resourceful make light of their difficulties and others, for a variety of reasons, make heavy weather of them. Moberg (1958) has shown how such tests may be employed for assessing sensory function.

It has been suggested that the movements of the human hand, as a whole, can be regarded as prehensile and non-prehensile and that the prehensile movements which comprise the most exact and intricate movements of the hand fall into two broad groups which are described by the terms power grip and precision grip (Napier 1956); that these two terms encompass the whole range of prehensile movement is attested by the observation that, should the hand be arrested during prehensile activity, it exhibits some phase of one or other grip, or sometimes a combination of the two (Figs. 1 to 3). In a *power grip* the object is held in a clamp formed by the flexed fingers and palm, the thumb acting as a stabiliser (Fig. 1)

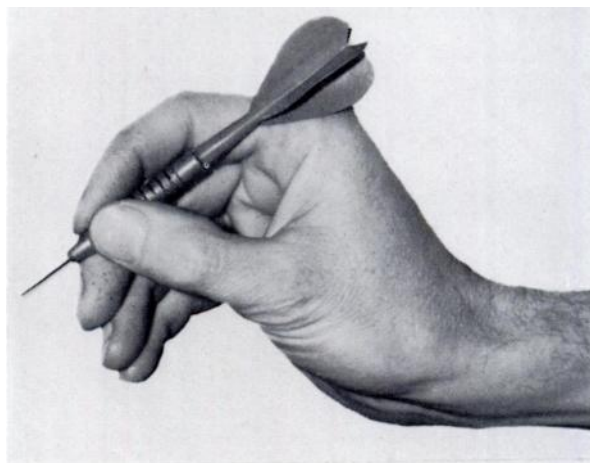


FIG. 4
The dorsiflexion of the wrist in a fine precision grip.



FIG. 5

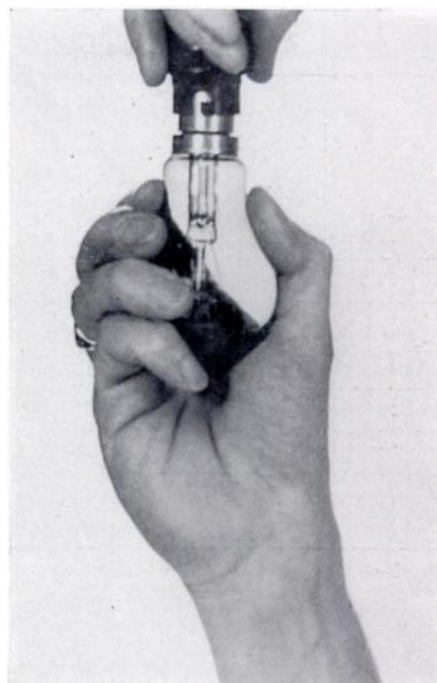


FIG. 6

Figure 5—The lugs of the electric light bulb are being engaged in the bayonet fitting of the socket (precision grip). Figure 6—The lugs are being locked home (power grip).



FIG. 7



FIG. 8

Case 1,967. Low lesion in continuity of ulnar nerve. Figure 7—Power grip. Figure 8—Precision grip.

TABLE I
SUMMARY OF NERVE INJURIES STUDIED

Affected nerve	Number of patients			Range of ages at time of injury (years)	Nature of injury				Sutures	Lesion in continuity
	Total	Male	Female		Gunshot wound	Laceration	Fracture	Pressure		
Ulnar . . .	59	59	—	18-40	55	4	—	—	41	18
Median . . .	32	31	1	19-35	28	3	—	1	25	7
Radial including posterior-interosseous . . .	14	14	—	17-37	12	1	1	—	12	2
Median and ulnar	34	33	1	18-35	30	4	—	—	21	13
Median and radial	5	5	—	21-31	5	—	—	—	2	3
Median, ulnar and radial . . .	10	10	—	20-30	10	—	—	—	4	6

METHODS

A full history was taken and included information about employment and hobbies. The range of passive movement of individual joints, the presence or absence of contractures of muscles, power of individual muscles and results of sensory stimulation with 1 gramme von Frey hairs and pinprick, were recorded in all cases. Voluntary power was recorded on the M.R.C. scale* (Seddon 1949). Some patients were given a more detailed sensory examination employing graded stimuli and tests for two-point discrimination. Stereognosis and ability to judge weight were tested by the use of paired plastic shapes, one of each pair having a weight embedded in its substance. The ability to judge textures was tested with a range of materials or, if the patient was unfamiliar with textiles, with graded samples of glass paper. Sensory discrimination was tested in both hands.

Power grip was tested by using wooden or plaster cylinders, approximately six inches long and of diameters ranging from half an inch to two and a half inches. For precision grip three balls were employed; the smallest was a marble, the second a squash ball and the largest a rubber ball three and a half inches in diameter; when tests for the finer grades of precision were required the patient was asked to pick up a pin or a needle. The stability of grip and its departure from normal were noted and, when possible, progress was recorded photographically (Figs. 18 to 26).

As already pointed out, it is the purpose of the movement rather than the shape of the object which influences the choice of grip employed (Napier 1956). For example, a wooden cylinder may be held in either of the two postures: as a pen it is held in a precision grip and as a hammer in a power grip. Similarly, a sphere such as an electric bulb is held in a precision grip whilst the lugs are being engaged in the bayonet fitting and in a power grip as it is locked home (Figs. 5 and 6).

RESULTS

Ulnar nerve injuries—Power grip was more affected than precision grip (Figs. 7 and 8) and, as expected, the more complete the palsy the greater was the disability. However, even in low

* 0=No movement detected. 1=A flicker of movement in the muscle belly. 2=Movement of the relevant joint with gravity eliminated. 3=Movement of the joint against gravity. 4=Movement against resistance. 5=Movement against resistance clinically indistinguishable from normal.

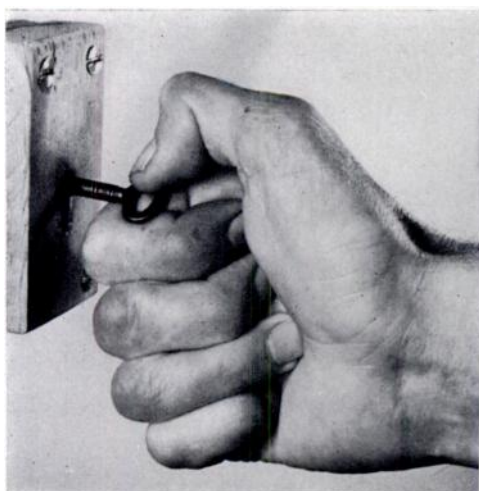


FIG. 9

Case 958—Suture of ulnar nerve 11 centimetres above the medial epicondyle. Action of flexor pollicis longus compensating for paralysed adductor pollicis. (Froment's sign.)



FIG. 10

Ulnar nerve lesion. Fingerprints demonstrating R—the normal hand; L—the affected hand. Note the diminished spread of the digits and trophic changes in the left hand.

lesions with intact long flexors, disturbance of power grip was severe unless the intrinsic muscles were capable of contracting against resistance. Disturbance of power grip was most marked when gripping small cylinders. The three factors responsible for the inefficiency of the grip were, firstly, the inability to wrap the fingers fully round the object, secondly the failure of elevation of the hypothenar eminence, and thirdly the ineffective clamping action of the thumb due to weakness or paralysis of adductor pollicis (Fig. 7). The loss of adductor pollicis is only partly compensated for by the action of flexor pollicis longus (Fig. 9).

The impairment of precision grip for large objects was due to a lack of spread of the digits, the result of weakness or paralysis of abductor minimi digiti and of the dorsal interossei (Fig. 10). Impairment for small objects (Fig. 11) was due to instability of the thumb and the unrotated index finger, the results of paralysis of adductor pollicis and the first dorsal and second palmar interossei respectively.

Contractures of flexor digitorum profundus to the two inner digits and of the interossei, with or without secondary changes in the metacarpophalangeal and interphalangeal joints, aggravated the handicap with respect to power grip in particular (Figs. 12 and 13).

A "lively" knuckleduster splint (Capener 1946) improves the grip (Figs. 14 and 15) and lessens the tendency to the formation of contractures (Bowden 1954).

Median nerve injuries—Interference with power grip was relatively slight in comparison with the serious disturbance of precision grip. In high lesions the grip of small cylinders was impaired by weakness or paralysis of both the long flexors of the index finger (Fig. 16).



FIG. 11

Case 958 (see Fig. 9)—Note the lack of lateral rotation of the index finger and the abnormal position of the thumb due to paralysis of adductor pollicis.

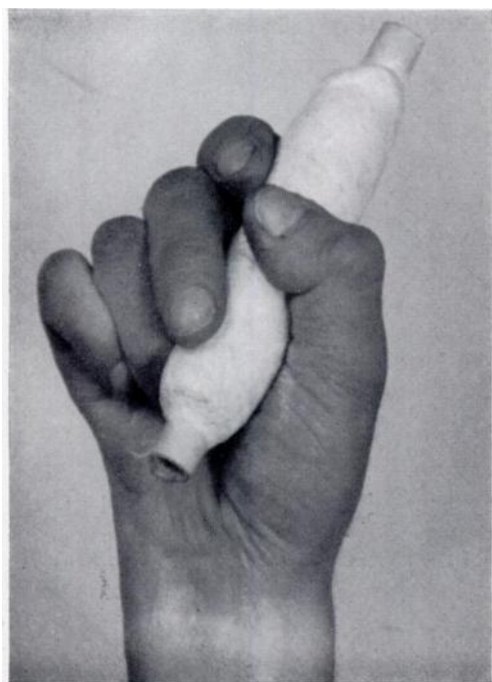


FIG. 12



FIG. 13

Case 972. Figure 12—Low lesion in continuity of ulnar nerve with severe contractions of flexor digitorum profundus. Figure 13—Note the obliquity of grip before and after amputation of the grossly contracted digits.

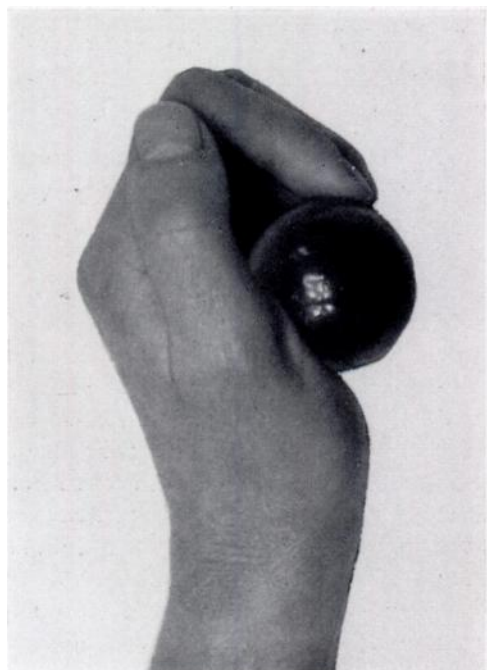


FIG. 14



FIG. 15

Case 1,163. Figure 14—Suture of the ulnar nerve 8 centimetres above the medial epicondyle. Figure 15—Note the improvement in grip with a lively knuckleduster splint.

A similar loss in the case of the middle finger was usually partly compensated for by the passive pull on flexor digitorum profundus by the intact ulnar half of the muscle. With large cylinders defects of the grip were more evident, because even in low lesions with intact flexors of the digits loss of abduction and rotation of the thumb prevented it from stabilising and reinforcing the grip (Fig. 17).

Precision grip was grossly impaired even when the long flexors were intact. The main factor on the motor side was loss of abduction and rotation at the carpo-metacarpal and



FIG. 16

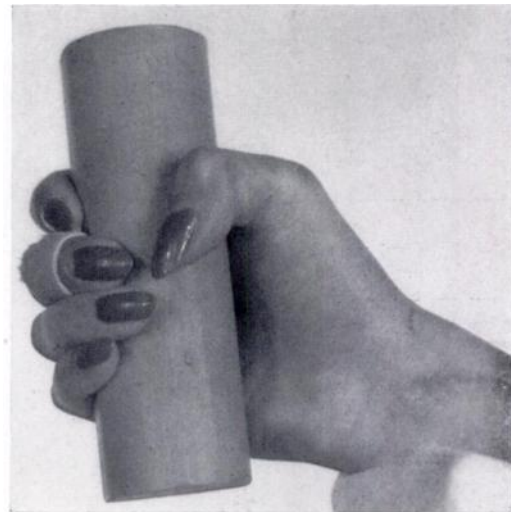


FIG. 17

Figure 16. Case 799—Suture of the median nerve 22 centimetres above the medial epicondyle. Note i) the signpost deformity which impairs the stability of the power grip; ii) the unrotated thumb. Figure 17. Case H.10—Suture of median nerve at wrist in March 1952. (The distribution of the nerve in this case was anomalous; note the small area of loss of sensibility in Figures 18 to 26; flexor pollicis brevis was partially supplied by the ulnar; abductor pollicis brevis and opponens were wholly supplied by the median nerve.) Impairment of the power grip as a result of lack of rotation of the thumb.

metacarpo-phalangeal joints of the thumb due to paralysis of the abductor pollicis brevis. In median nerve injuries the loss of cutaneous sensibility was an additional and significant factor.

Figures 18 to 26 illustrate the progress of a patient after suture of the median nerve at the wrist. The abductor pollicis brevis and the opponens pollicis were paralysed but the flexor pollicis brevis was, in this instance, wholly supplied by the ulnar nerve. The small area of sensory loss was due to the unusually large cutaneous distribution of the ulnar and radial nerves. The first signs of a return towards a normal pattern of function appeared when the opponens pollicis and abductor pollicis brevis were contracting against gravity (Figs. 22 and 25) and there was still a slight deficiency when they were acting against resistance. Although only two of the intrinsic thenar muscles were affected the disability was great.

Contractures of the active adductor pollicis and of the capsules of the joints of the thumb, and overstretching of abductor pollicis brevis counteracted the results of reinnervation in a number of patients. A relatively minor limitation of movement in joints of the thumb—particularly the metacarpo-phalangeal joint—had a disproportionately serious effect on function (Napier 1952).

Radial and posterior interosseous nerve injuries—Both types of grip were affected and the defect was more apparent with large than with small objects. Impairment of power grip was due to the wrist drop, the absence of synergic activity in the extensors of the wrist preventing the

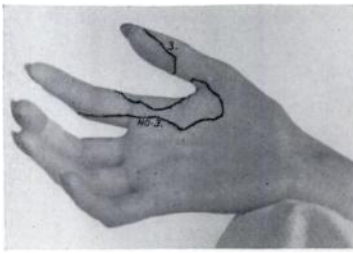


FIG. 18

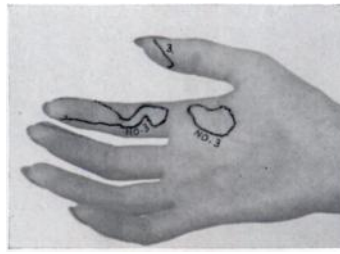


FIG. 19

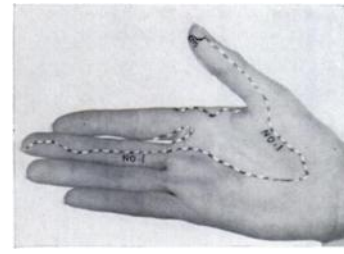


FIG. 20

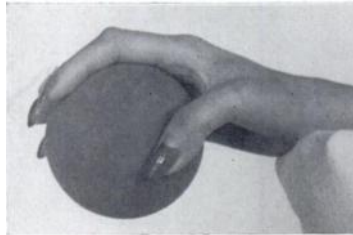


FIG. 21

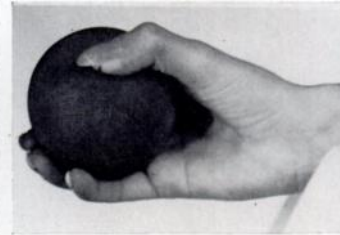


FIG. 22

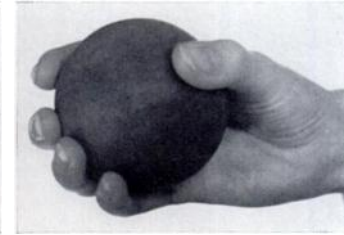


FIG. 23

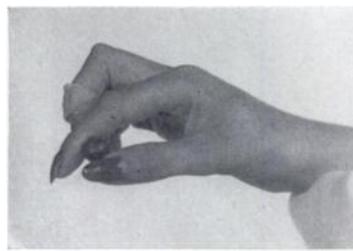


FIG. 24



FIG. 25



FIG. 26

Case H.10—Figures 18 to 20 show progress of recovery of tactile sensibility. Figures 18 and 19—Loss of response to No. 3 von Frey hair; Figure 20—No loss of response to Nos. 2 and 3, but to No. 1 hair only. Figures 21 to 23 and 24 to 26 show improvement in coarse and fine precision grip.

more efficient flexion of the digits (Fig. 27). When the radial extensors of the wrist were active, weakness of ulnar deviation due to imbalance between the abductors and adductors of the wrist reduced the efficiency of grasping large cylinders.

The loss or weakness of extension of the wrist was the main factor contributing to impairment of the precision grip; paralysis of abductor pollicis longus was a secondary factor, particularly when the object was large and necessitated wide abduction of the thumb.

An effective splint corrects the wrist and finger drop, and compensates for the loss of extension of the thumb and paralysis of abductor pollicis longus. In some patients, however, crippling contractures had developed in all the extensors after wearing, in the early stages, a certain type of cock-up splint which virtually immobilised the wrist. These contractures in the extensors of the thumb were serious for they significantly limited abduction and rotation and flexion of the joints of the digit. In long established cases of radial palsy where there are no contractures and there is little danger of them developing at the later stage, a fixed cock-up splint can, however, materially increase the efficiency of grip (Fig. 28).

Combined nerve lesions—The commonest form of combined lesion is that affecting both median and ulnar nerves (Nicholson and Seddon 1957) (Table I). Even in low lesions in which the long flexors of the wrist and digits are spared, disablement of prehensile function is considerable. The thumb deprived of all intrinsic muscles can contribute little towards prehension (Figs. 29 and 30). Both power and precision grip are equally affected and the hand is functionally

little more than a hook. In high lesions even this hook-like action may be impossible owing to the presence of contractures in the long flexor muscles that may prevent the digits from being sufficiently extended to contain a cylindrical or spherical object. Considerable functional improvement can be obtained by the use of a suitable splint (Figs. 31 and 32) that corrects the paralytic deformity of the thumb.

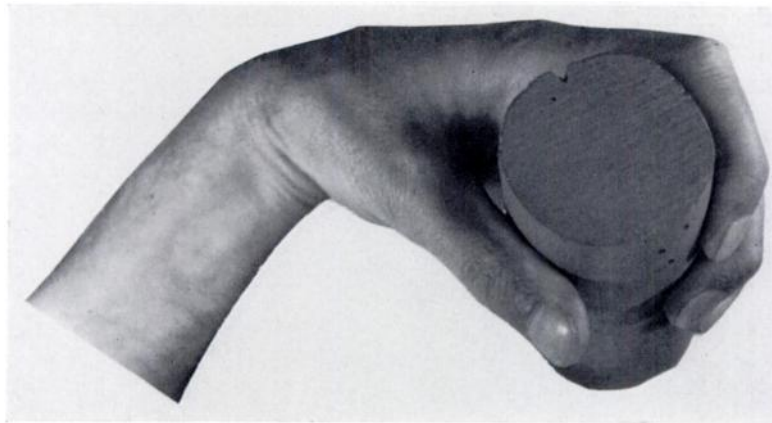


FIG. 27

Case 786—Impaired power grip due to a wrist drop following irreparable damage to the radial nerve.

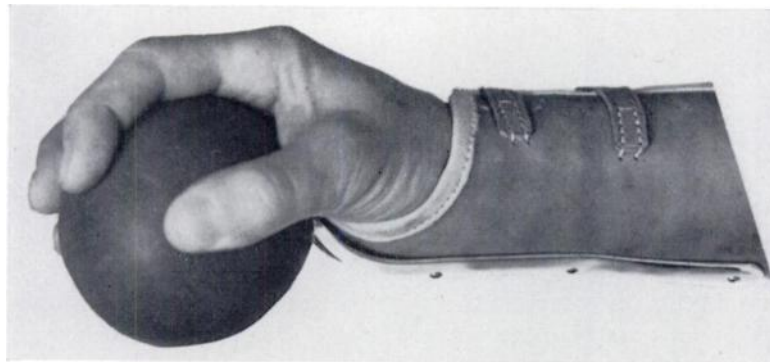


FIG. 28

Case 896—Lesion in continuity of the radial nerve with poor recovery. The patient was unwilling to submit to a tendon transplant. Note the effective grip when wearing a cock-up splint designed to meet his particular requirements.

Other combined lesions have been studied including median and radial nerve lesions and median, ulnar and radial lesions, but they will not be described, as the disabilities associated with these lesions are embodied in the accounts given above of single nerve lesions.

DISCUSSION AND CONCLUSIONS

The effects of peripheral nerve injuries upon skilled and unskilled movements are generally understood and have been summarised recently (Bowden 1958). The part played by the median nerve in prehensile movements of precision and by the radial nerve in stabilising and determining the position of the wrist for prehensile function are well known. Less well known are the effects of ulnar nerve lesions on the functional efficiency of the hand. Whilst there is full recognition of the loss of skilled percussive movements (for example, those used in typing)

that follow damage to the ulnar nerve, the effect upon prehension may be less well appreciated. It is generally understood that an ulnar nerve lesion in a skilled worker is not an insuperable disability and it might be supposed that it constitutes even less of a disability in an unskilled or manual worker. This, however, is far from the truth, for with certain reservations mentioned below, the ulnar nerve is the nerve of the power grip. The stability of the grip depends on the pressure and counter-pressure provided by the fourth and fifth digits and the hypothenar eminence on the one side and the counter-pressure of the thumb on the other. This point is illustrated by the history of a Metropolitan Water Board turn-cock whose right-sided power grip was impaired due to the presence of an ulnar paresis. Although right-handed, this patient found it necessary to use his left hand for the preliminary loosening and final tightening of the cocks against the resistance of the thread; the intermediate phases of the operation which required little power were performed by the dominant though weaker right hand.



FIG. 29

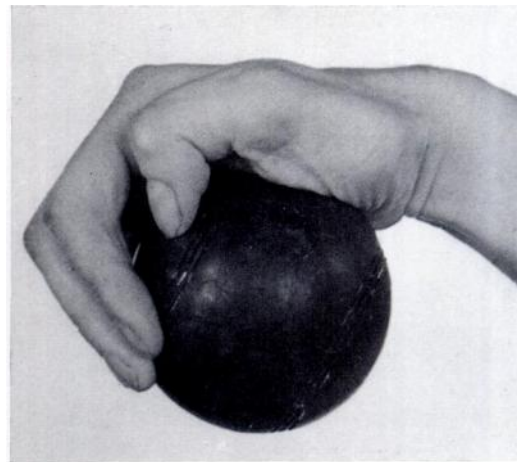


FIG. 30

Case 745. Figures 29 and 30—High median and ulnar nerve lesions resulting in gross disturbance of the power and precision grips.

The findings in this study suggest that, given a stable wrist, the ulnar nerve is the nerve of the power grip and the median the nerve of the precision grip. The concept of a complete neurological and functional dichotomy, however, breaks down on several points. Firstly, adductor pollicis (ulnar nerve) is used in both grips to move the thumb towards the index finger. Loss of this muscle affects power and precision to different degrees. In the power grip the role of the thumb in applying counter-pressure is severely impaired, while in the precision grip, in which less force is required of the thumb than the index finger, the loss of the muscle is not so serious. Secondly, the thenar muscles (median nerve), which are clearly of critical importance in the precision grip, also contribute to the stability of the metacarpo-phalangeal joint during power gripping. Some loss of power, particularly with large cylinders, can be observed in the power grip where the thumb requires to be considerably abducted; with more slender cylinders the disability is less marked. Thirdly, the flexor pollicis longus (median nerve) is of critical importance in the precision grip but also plays an important part in the power grip. The loss of flexor pollicis longus can be compensated for in the power grip by hyperextension of the distal phalanx and the use of the thumb as a whole, rather than the terminal phalanx alone, to provide the necessary counter-pressure. Thus, although the loss of flexor pollicis longus affects the efficiency of both grips, it has its most profound effect upon the precision grip. Lastly, the first dorsal and second palmar interossei (ulnar nerve) contribute to the stability of the index finger during index-thumb opposition; the loss of

these muscles reduces the strength of the pinch movement and promotes the use of the middle finger during precision movements as a prop and stay to the index finger.

Although the two grips are not fully discrete from the point of view of the nerve supply of the component muscles, it is apparent from the foregoing results that *functionally* the brunt of an ulnar nerve lesion falls on the power grip and that of a median nerve lesion upon the precision grip. Therefore, in spite of the absence of clear-cut neurological dichotomy, this



FIG. 31

Case 1,782—Severe lesion in continuity of the median nerve and suture of the ulnar nerve 8 centimetres above the medial epicondyle.



FIG. 32

Case 1,782—Note the effect upon the thumb of a modified Highet type of median nerve splint.

study provides clinical support for the concept that the prehensile movements of the hand as a whole may be regarded in terms of two fundamental movement complexes.

The use of the tests has demonstrated that an apparently mild contracture of the muscles and of the joint capsules in the hand, and in particular of the thumb, has a grave effect upon function. They have shown the deleterious effect of the insidious, and at times unnoticed, contractures of the interossei and capsules of the metacarpo-phalangeal joints, thus emphasising

the need to prevent contractures by passive movements and by active or "lively" splinting (Capener 1946) which not only corrects the paralytic deformity, but also encourages repeated daily use of the hand.

The tests described do not provide a short cut to diagnosis or prognosis but it is suggested that they are a useful adjunct to the full routine motor and sensory examination, particularly in the later stages when the patient's capacity for work is under assessment. They offer a simple, repeatable and objective method of estimating the prehensile function of the hand as a whole. The need for such functional tests has already been stressed by Moberg (1958). The defects of prehension can be analysed in detail in each case and the effectiveness of splints tested. The patient can be helped to select the optimum size for handles of tools and utensils and to choose a suitable definitive employment. The prehensile requirements of any manual employment can be studied in terms of power and precision grip.

SUMMARY

1. Power and precision grip (Napier 1956) were tested in 154 patients with nerve injuries.
2. The results are described, illustrated and discussed and it is suggested that these tests provide a simple, repeatable and objective method of assessing prehensile function of the hand as a whole.

Grateful thanks are due to the Governors of the Royal Free Hospital through whose kindness it was possible for us to conduct a follow-up clinic for peripheral nerve injuries from 1947-54 inclusive; to the Medical Research Council and the Endowment Fund of the Royal Free Hospital for generous financial support. It is a pleasure to record appreciation of Mrs E. Broome, secretary and research assistant, and Mrs P. Thomas, Miss F. Ellis and Mr A. L. Wooding of the Photographic Departments of the Royal Free Hospital School of Medicine and St Thomas's Hospital Medical School. Grateful acknowledgment is made to the Editor of the *British Journal of Physical Medicine* for permission to use Figures 14 and 15.

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