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Henry H. Kessler

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Medicolegal Aspects of Upper Extremity

HENRY H. KESSLER*

The ability to achieve the satisfaction of man's major desires, interests and urges can be realized only through the widest application of his capacities and powers. Prehension, the specific function of the upper extremity, satisfies this ideal. Through the use of the hand and arm, man has been able to exploit his brain to the fullest. In this respect the hand is an extension of the brain. It steers the horse, holds the flute, builds a house, writes a book, grasps a sword.

Hand as Tool. It is not only a tool in itself but it permits the employment of tools like the hammer and tongs, the fork and the knife, the chisel and the file, thus far exceeding the crude activity of the teeth, beak, horns and tusks of animals.

Hand as Sense Organ. The hand is also a sense organ. It is the eye of the blind. In the tip of the finger lies the ability to perceive depth, size, weight, form, smoothness and roughness.

Component Parts. An analysis of the structure of the upper extremity reveals two essential structural components. There is first of all the hand radical, the prehensile tool which gives the upper extremity its specialized character. There is also the compound lever composed of the bones, the muscles, and the joints moving the wrist, elbow, and shoulder which permits the widest application of the hand radical.

HAND RADICAL

Mechanical Analogues. Among the many activities of the normal hand in the routine of everyday life, we may find five functions which can be best described by their mechanical analogues.

(1) The *hook* is formed by the incomplete flexion of the four fingers on the palm of the hand. This supplies a carrying function to the hand.

*Orthopedic surgeon, Newark, New Jersey; M. D., Ph. D.; formerly Captain in the Medical Corps, U. S. N. R., and served as medical director of the New Jersey Rehabilitation Clinic.

(2) The *ring* is formed by complete flexion of the fingers, the tips of the fingers turning to oppose the thumb.

(3) The *forceps* action is obtained by the opposition between the thumb and the index finger.

(4) The action as *pliers* is obtained in a similar manner as the forceps action except that the flat of the index finger is used and a greater amount of power is exerted.

(5) The *paperweight* is simulated by the pushing or pressure effect of the entire hand without the aid of the fingers.

Basic Functions. These five functions may be multiplied or modified a thousand fold, giving effects that provide an infinite range to human ideas and desires. It would be impractical to attempt to use so wide a range of movements or their mechanical analogues as a measure of the usefulness of the hand radical. These movements and functions, however, can be arbitrarily condensed into three essential elements.

(1) Grasping power for small objects (fountain pen) between the folds of the fingers;

(2) Grasping power for large objects (glass tumbler) between the fingers and the palm of the hand;

(3) Opposition between the thumb and the tips of the fingers.

These functions can be easily observed and charted and provide a simple yet relatively accurate index to the functional value of the hand radical.

Values. An examination of these three basic functions in a large series of routine and special activities would reveal a fairly close or equal value both in the incidence of their use (quantitative effect) and in the character of their employment (qualitative effect). In arriving at an estimate of the relative and respective values, consideration should be given to the possibility of the substitution of one combination by another. The thumb fingers combination can simulate the palm fingers. The reverse is not true so that the former function should be given a higher value. Therefore, it would be reasonable to ascribe to the thumb fingers combination a value equal to forty per cent of the function of the hand; the grasping power for small objects between the folds of the fingers, thirty per

cent, and the grasping power for large objects between the fingers and the palm, thirty per cent.

ARM RADICAL

The utility of the compound lever, guiding and directing the tool, the hand, will depend on three essential functional components: (1) the range of motion of the joints of the arm, (2) the strength of the muscles, and (3) the nervous control of the whole arm or coordination.

Motion

The three major joints in the upper extremity are the shoulder, the elbow, and the wrist joints. Each joint is different in character, the shoulder being a ball and socket joint (like a universal joint), the elbow being a hinge joint (moving in one place only) and the wrist joint being a combination sliding and turning joint giving the effect of a universal joint. Limitation of movement of these joints can be measured by instruments known as protractors, arthrometers or goniometers. When compared to the sound arm it is easy to obtain the loss of motion for each joint. The interpretation of these differences however has been given little consideration and various systems of computation provide wide divergences as a result.

Computation. A simple method is to ascribe an equal value ($33\frac{1}{3}\%$) to each joint, shoulder, elbow and wrist. The next step is to consider the greatest loss of motion in any direction as representing the loss of motion for the entire joint. For example, external rotation (turning out) of the upper arm (through the shoulder joint) may be reduced 20% as compared to the sound arm while abduction (bringing the arm away from the body to the side) may be reduced 60%. The latter figure is used as the index of loss of motion for the entire joint. Since the entire joint has only a value of a third of the total range of movements of the three joints, the above figure is therefore translated into its final figure of 20% (60% of $33\frac{1}{3}\%$).

Where there is only one joint involved that is taken as the value for the loss of the motion factor in the arm radical. Where more than one joint is involved the added loss of the two or three joints would be considered as the loss of the motion factor for the arm radical. For example, the shoulder may show a loss of motion of 60% (of $33\frac{1}{3}\%$) or 20% of the total arm motion, the elbow may show a loss of 30% (of $33\frac{1}{3}\%$) or 10% of the total arm motion while the

wrist may show a loss of 15% (of $33\frac{1}{3}$) or 5%. The loss of the motion factor in the arm radical would be 20% plus 10% plus 5% or 35%.

Muscular Strength

The next functional component to be tested is that of muscular strength. Many of the methods and instruments used in the measurement of strength are fallacious. Ergographic and ordinary dynamometric methods fall into serious error. The fish scale type of spring balance is a more adequate means for making these determinations. A large hooked strap to which the balance is attached is passed around the arm or leg and the resistance to pull registered.

All the muscles of the arm can be tested and compared to the sound arm. Contrary to accepted ideas, the differences in strength between the two upper extremities is normally insignificant. The detailed testing with a series of different sized spring balances may be simplified by testing only five of eleven important muscle groups: (1) the anterior deltoid, (2) the extensors of the forearm, (3) the flexors of the forearm, (4) the extensors of the wrist and (5) the flexors of the wrist. The sum total is added and compared with the sum total of the same groups of muscles in the sound arm. The percentage difference represents the loss of the strength component in the arm radical.

Coordination

Isolated muscle action does not exist. All muscles combine their efforts so well that the real grouping of muscles is functional and not anatomical. This coordination determines the chronological sequence in which one group after the other takes its place in muscular work. The importance of coordination can be better appreciated if one realizes that it is as indispensable as the contraction of the muscle itself, since unorderly contractions would lead to tearing strains and dislocations rather than purposeful movement.

The precise and gradual association of muscular movement then is not a function of the muscular system but of the nervous system. In general, each individual fiber of a muscle is connected with a nerve cell in the spinal cord, through the nerve fiber of a motor nerve. In order for a muscle to contract these nerve cells must be stimulated. This can be done by the definite action of the will, which sets up an excitation in the brain cells, which in turn by

nerve fibers act upon the centers in the spinal cord. Most movements, as the step in walking, are for the most part not fulfilled by the act of the will but by nerve cells stimulated involuntarily through the end organs which translate stimuli from the outside world into sensory impressions. A sensory stimulus can initiate movements without the intervention of the brain (reflex).

Test for Coordination. The efficiency of a muscle then depends not only upon its strength but also on its ability to respond to the excitation of a nerve stimulus which directs its action. Of two men with equal strength, one will strike a harder blow because of greater motor coordination in his muscles that enables him to direct it at his target with more efficiency. A simple test for coordination which takes into consideration sensory incapacity relies on the placing of small pegs into holes of the same diameter. The number of pegs placed is compared with that of the normal hand in the same specified time.

Interpretation. An examination of the arm radical after fractures, nerve injuries, muscle, tendon and joint injuries will reflect its loss of function on the subnormal range of motion, impaired muscular strength and defective coordination. In a given case there may be a thirty-five per cent loss of motion, a twenty per cent loss of strength and ten per cent loss of coordination. How shall we interpret these values in computing the loss of function of the arm radical? It is impossible to weigh these functional components on any but clinical grounds. A practical method consistent with clinical judgment is to take the maximum figure (thirty-five per cent, the loss of motion) as representing the loss of function of the arm radical.

TECHNIQUE OF EVALUATION

Having obtained our figures indicating the loss of function of the arm radical and the hand radical, how shall we compute the disability of the whole extremity? We have already said that the arm subserves the hand, all its activities culminating finally in the action of the hand and fingers. That is true up to a certain point. It is possible for the movements of the hand to be carried out without motion taking place in the remaining joints of the arm radical. These movements however would be so restricted in its sphere of activity as to remain practically useless.

In substance both radicals are interdependent. The disability of the entire extremity will therefore depend on the maximum disability of either radical. A chain is only as strong as its weakest link.

For example, if the arm radical suffered an actual loss of function of twenty-four per cent and the hand radical had suffered a loss of forty per cent (loss of the thumb fingers combination), the whole extremity would be disabled forty per cent, the maximum of the two disabilities. If the arm radical were disabled sixty-five per cent and the hand radical were disabled thirty per cent (grasping power for small objects between the folds of the fingers), the disability for the entire extremity would be sixty-five per cent. The disability of the entire extremity is as great as the disability of its most affected part.

FRACTURES OF THE UPPER EXTREMITY

General Considerations. The effect of fractures on the upper extremity will depend upon the character of the alignment of the fragments, the union of the fracture and the concomitant injury to the soft parts. These factors in turn manifest themselves in the general utility of the extremity as determined by the physiological elements of function, namely, (1) motion of the joints, (2) strength of the muscles and (3) coordination from the brain through the peripheral nerves.

Clavicle

General Prognosis. The general prognosis after fracture of the clavicle is good. Union occurs as a rule with a relatively small amount of deformity. Despite this deformity the function of the arm is seldom interfered with. The rare complications which render the prognosis poor are injuries to the subclavian artery and vein, to the brachial plexus of nerves, and to the lung from pressure by excessive callus formation.

Average Period of Incapacity. Union in fracture of the clavicle generally takes place in twenty-one days to six weeks.

Permanent Disability. The permanent disability that may result from fractures of the clavicle is manifested by a slight diminution in the strength of the arm. Rarely is there any limitation of motion and then only in the presence of peri-arthritis (inflammation).

tion about the joint). In a series of two hundred thirteen cases the average disability was five to ten per cent.

Scapula

General Prognosis. The functional prognosis in fractures of the scapula depends on the location of the fracture. Because of its peculiar shape and varying thickness it is good except where the break is through the neck and glenoid cavity. In the latter instances the joint is involved and accounts for the restriction of motion that follows.

In fracture of the body, union occurs in four weeks. This type of fracture may be complicated by overriding of fragments and excessive callus on account of the difficulty in maintaining accurate apposition of the fragments. With an associated injury to the bursa and joint capsule there may be some permanent disability.

In fracture of the angle of the scapula there may be a marked diminution of strength due to shortening of the bone itself.

Fractures of the spine of the scapula are the most frequent variety. The prognosis is good.

Fracture of the acromion process is often followed by fibrous union instead of bony union but the disability is rarely severe.

Fractures of the neck are generally followed by restriction of motion of the shoulder and impairment in the strength of the arm to a moderate degree.

Fractures of the coracoid process may occur alone but are generally accompanied by other fractures of the scapula.

Average Period of Incapacity. In fractures of the body and spine the average period of incapacity is two to three months; in fractures of the neck three to four months.

Permanent Disability. The chief causes for permanent disability following fractures of the scapula are vicious union of the fracture which interferes with the movements of the shoulder or renders them painful, and extensive atrophy of the shoulder group of muscles causing marked impairment of strength of the arm. The average disability in a series of thirty-two fractures of body and spine was fifteen to twenty per cent of the arm.

Shoulder

General Considerations. Fractures about the shoulder are considered as an entity because of the primary effect of all fractures in this region, namely, limited movement of the shoulder joint. In these are included:

- Fractures of the neck of the scapula (previously considered)
- Fractures of the head of the humerus
- Fractures of the anatomical neck of the humerus
- Fractures of the surgical neck of the humerus
- Fractures through the tuberosities of the humerus
- Fractures (isolated) of the greater or lesser tuberosity of the humerus
- Separation of the upper epiphysis of the humerus

General Prognosis. This depends on the character and extent of the injury and the type of treatment. The chief complications are restriction of movement of the shoulder, injury to the circumflex nerve and peri-arthritis.

Average Period of Incapacity. In the average case this extends from ten to twelve weeks. In the complicated case it may be prolonged to six to eight months.

Permanent Disability. Lack of mobility of the shoulder joint is the chief disabling factor in injuries about the shoulder. Strength and coordination are secondary considerations. Motion may be restricted by vicious union, excess callus, shortening of muscles or by peri-arthritis.

In six cases of fracture of the anatomical neck of the humerus this disability ranged from ten to twenty-five per cent.

In twenty-five cases of fracture of the surgical neck the disability ranged from ten to seventy per cent.

In fractures of the tuberosities the average disability was thirty-three and one-third per cent. The lowest was twenty per cent, the highest, sixty-six and two-thirds per cent.

In separation of the epiphysis which occurs in younger individuals there may be complete recovery with no disability or moderate disability, which in three cases ranged from five to twenty-five per cent.

Shaft of Humerus

General Prognosis. The chief complication of fracture of the shaft of the humerus is injury to the musculo-spiral nerve. The principal unfavorable end result is non-union. Other minor complications are persistent pain and atrophy, traumatic arthritis of the shoulder, shortening and vicious union and excess callus formation. Stiffness in the elbow following fracture of the shaft occurs more commonly in fractures closer to the elbow joint. However, in badly displaced fractures even at the middle third of the humerus stiffness may follow. Injury to the blood vessels, either the brachial artery or vein, may be the result of the force causing the fracture or may follow from injury by sharp bone fragments. In rare cases the disturbance of circulation may be followed by loss of radial pulse and gangrene.

Average Period of Incapacity. Ordinary union takes place in four to six weeks in the most favorable cases. If at the end of that time there is no evidence of callus, the condition may be considered one of 'delayed union. With firm union and the disappearance of the stiffness of the adjacent joints due to immobilization, the injured should be ready to work in nine to eleven weeks in favorable cases. Complications, such as non-union and nerve injury, obviously require a prolonged period of temporary disability.

Permanent Disability. The structural end results that cause permanent disability in uncomplicated fracture of the shaft of the humerus are:

1. Shortening
2. Vicious callus
3. Atrophy
4. Stiffness of the adjacent joints, the result of the injury or immobilization

The functional sequelae are:

1. Impairment of strength of the arm
2. Limitation of motion of the elbow or shoulder joint
3. Slight reduction in the coordination of the arm and hand.

In a series of ninety-three cases the average permanent disability was ten to fifteen per cent of the arm. In the presence of non-union the disability approaches seventy-five per cent of the arm.

Elbow

Lower End of the Humerus. The following types of fracture may occur in the lower end of the humerus:

1. Supracondylar fracture
2. Fracture of the internal condyle
3. Fracture of the internal epicondyle
4. Fracture of the external condyle
5. Intercondylar or T or Y shaped fracture
6. Separation of the epiphysis
7. Fracture of the articular process
8. Fracture of the trochlea

The chief effect of all these fractures is on the range of motion of the elbow joint. The important complications are:

1. Injury to the musculo-spiral nerve
2. Injury to the ulnar nerve
3. Ischemic sclerosis
4. Myositis ossificans
5. Arthritis of the elbow joint
6. Non-union
7. Ankylosis of the elbow joint
8. Muscular atrophy

These complications prolong the period of incapacity and produce sequelae which explain the serious impairment of capacity to work.

Upper End of Radius and Ulna. Because the radius and the ulna form a part of the elbow joint, fractures of these two bones at this site are considered here.

The fractures encountered are:

1. Olecranon process of the ulna
2. Coronoid process of the ulna

3. Head of the radius

4. Separation of the upper epiphysis of the radius

Average Period of Incapacity. In the absence of complications it may be said that functional recovery in the average case occurs within three months and at the latest in six months.

Permanent Disability. The chief structural end result that causes disability is the malalignment of fractures of the lower end of the humerus producing a disturbance in the carrying angle of the elbow. This angle is formed by the lateral border of the humerus with the lateral border of the forearm in a supinated (turned out or palm up) position. It is usually one hundred seventy-three degrees in the male and one hundred sixty-seven degrees in the female. If this angle is increased outward (more obtuse) it produces a deformity known as cubitus valgus. Increase of the inward angle (more acute) produces a gunstock deformity or cubitus varus. The changed angle impairs the *strength* of the arm through the changed conditions of leverage.

The frequent interference with motion following fractures about the elbow joint is the most common functional end result. This impairment may be slight, moderate or complete. Slight degrees of impairment such as ten degrees of flexion or extension cause no greater disability than ten per cent of the arm. Inability to flex the elbow joint beyond a right angle, regardless of the degree of extension, causes inability to perform many of the routine pursuits of life. The disability in this case approaches twenty-five to thirty-three and one-third per cent of the arm. Inability to extend beyond the right angle regardless of the flexing ability is not as serious and produces a disability of twenty to twenty-five per cent. Complete restriction of motion causes a disability that depends on the angle at which the joint is ankylosed. The most favorable angle is eighty degrees (thirty-three and one-third per cent loss of the arm because of the total loss of the motion factor for that joint). The most unfavorable position is the straight or extended position (sixty-six per cent). Here the lost motion thirty-three and one-third per cent is exceeded by the loss of strength sixty-six per cent. Between the two, corresponding values can be ascribed.

Forearm

General Prognosis. The radius and ulna are clothed with many muscles and joined by a thick interosseus membrane which keeps

them from spreading apart but thus forming a complicated mechanism. This complexity renders accurate reduction difficult and displacement of fragments is a common finding as an end result of these fractures. In isolated fractures of either bone, maintenance of reduction is rendered less difficult by the splint-like action of the remaining bone.

Average Period of Incapacity. Fractures of the radius and ulna heal in the average case in four to five weeks. Functional recovery may be delayed by complications as shortening, vicious callus and non-union.

Permanent Disability. Fractures of the shaft of the bones of the forearm situated at a distance from the joints do not cause any restriction of motion. However, the rotary movement of one bone on the other may be affected. This movement has two components: supination, turning out with the palm upward and pronation, turning in with the palm down. Such actions as eating, drinking, writing and doing one's hair are considerably dependent upon these motions.

Strength is always impaired in these fractures as a result of shortening of the bones from displacement, vicious union, non-union or muscular atrophy. Coordination is also moderately impaired since dextrous movement can only be brought into play when the mechanical position of the bones of the forearm are at their optimum.

Wrist

General Prognosis. Fractures about the wrist are among the most frequent in the entire category of accidental injuries.

Peculiarly enough many severe displacements and deformities are associated with good function while in some instances even accurate reduction is followed by impaired function. The prognosis is for the most part dependent on the position of the fragments, the age of the patient, the presence of intercurrent disease and the character of the treatment.

Average Period of Incapacity. The period of incapacity varies greatly. In the average case, young persons with good reduction of the fracture return to work in six to eight weeks. In older patients and those in whom rheumatic and other disease tendencies are present, the disability is prolonged beyond this period.

Permanent Disability. The estimation of permanent disability manifests itself chiefly in impairment of mobility of the wrist and fingers, especially grasping power for small objects. The arm radical is affected in its strength component to a moderate degree. In a series of 1108 cases the following estimates were made:

9	0	per cent	272	25	per cent	23	75	per cent
101	5	" "	207	33	" "	11	90	" "
84	10	" "	91	40	" "	4	100	" "
98	15	" "	51	50	" "			
117	20	" "	40	60	" "			

General Prognosis. Fractures of the carpal bones almost invariably cause protracted temporary incapacity and leave marked permanent disability. The frequent end results are impairment of grip, loss of sensation and stiffness of the wrist and fingers due to the involvement of the tendon sheaths.

Average Period of Incapacity. The period of temporary disability averages three to six months.

Permanent Disability. The permanent disability ranges from twenty to twenty-five per cent. The most frequent disabilities occur especially in fracture of the scaphoid bone which is commonly followed by non-union. Dislocation of the semilunar bone even after perfect reduction leaves a moderate impairment of function as a sequel.

Metacarpals

General Prognosis. These fractures are rarely treated adequately because they are regarded as minor injuries. As a result they are frequently followed by deformity and a moderate degree of disability.

Average Period of Disability. Because they are frequently disregarded the period of incapacity is short. For adequate rest and treatment to insure full recovery the hand should be immobilized at least four weeks.

Permanent Disability. Deformity may exceed functional disability. The functional impairment will depend on the number of metacarpals injured as well as the site of fracture. In the mild cases a residual disability of five to ten per cent follows. In the more severe cases the disability may be as high as forty per cent.

Phalanges

General Prognosis. The most common sequelae are stiffness of the joints and tenosynovitis with associated loss of motion. Motion is the life of the finger. The strength component plays no great part. The loss of motion is the loss of function to the finger and can be easily measured with a protractor taking the corresponding finger of the other hand for comparison.

Average Period of Incapacity. Fractures of the phalanges usually unite in three to four weeks. Incapacity lasts from four to six weeks.

Permanent Disability. Where the joint of the finger is partially limited after injury the percentage loss is measured as that portion of the total motion for the three joints of the finger. In complete stiffness or ankylosis of a joint the position in which the joint is held is given additional weight in the determination. In certain positions (extension) the finger is frequently rendered useless despite good motion in the remaining joints of that finger.

DISLOCATIONS

Mechanism. In the normal healthy joint, dislocation may occur as a result of external violence or as a result of muscular action. Falls from a height are a frequent cause of dislocation through direct force applied to the shoulder. The shoulder may also be "pulled out of joint" when wrenched by the action of a pulley or a transmission belt. Dislocation of the shoulder has also been observed following the throwing of a baseball and extending the arms over the head in "stretching."

It may be seen then that a slight force can produce dislocation when the mechanical conditions of leverage are favorable or where the joint is already the seat of disease. Dislocations frequently follow convulsive seizures in epileptics.

General Prognosis. With early diagnosis and reduction of the dislocation the ultimate disability is as a rule small. The pain and swelling generally subside within a few weeks and in the absence of complications almost complete restoration of motion takes place in about a month. In those past middle age and in those with evidence of arthritis in other joints, the prognosis must be guarded.

When reduction is delayed the chances of good functional restoration become less. The reduction itself becomes increasingly dif-

ficult. After a month some of the larger joints cannot be reduced without an open operation.

Complications. In general it may be said that complications resulting from the initial injury are uncommon and usually slight. Those following manipulation are more common and severe.

Injuries to the large vessels and nerves are uncommon but when they do occur they are very severe. A rare but dangerous complication is that of fat embolism. Here a small globule of fat is dislodged from the bone marrow and passes through the blood stream to act as a clot or thrombus finally striking the lungs and causing immediate death from shock.

The chief end result of all joint dislocations is embarrassment of the range of motion of the affected joint. This may vary from slight restriction to complete ankylosis.

Specific Joints

Sterno-clavicular Joint. Dislocation of this joint is usually caused by the shoulder being forced backward as a result of a fall. The dislocation is both difficult to reduce and to retain when reduced. The temporary disability is short being not more than four weeks. There is no impairment of shoulder motion but there may be a slight residual weakness in the whole extremity of about ten per cent.

Acromio-clavicular Joint. The most common history is a fall on the shoulder. The average period of disability is not longer than six weeks. Some of these injuries cannot be reduced by simple closed methods and require a plastic repair of the ligaments that are torn in the production of the dislocation. The permanent disability varies from five to thirty-three and one-third per cent depending on the presence of complicating arthritis of the shoulder.

Shoulder Joint. (Also referred to as the gleno-humeral joint because the humerus articulates with the glenoid cavity of the scapula). This is the most frequently dislocated joint in the body. This can be easily understood if we examine the anatomical conditions that predispose to it. The head of the humerus is quite large as it articulates with the glenoid cavity of the scapula to produce the action of a ball and socket joint. Apparently it retains its position not by the close fit of these two bones but by the powerful strength of the muscles of the shoulder. In infantile paralysis the

shoulder dislocates automatically since there is no strong force pushing or holding the head of the humerus in its normal position.

Dislocations that are reduced early leave little disability. Late reductions are accompanied by more serious restriction and complications such as arthritis of the shoulder. Recurrent dislocation with repeated episodes of dislocation requires operative surgery for adequate repair.

Elbow Joint. The most common type is the backward or posterior dislocation in which both bones of the elbow forearm are displaced backward on the arm. The severe injuries to the capsule and the lateral ligaments, despite a perfect reduction are the factors most responsible for residual functional disability following dislocation. Nerve injuries are not common but do occur while a later menace is the occurrence of myositis ossificans. Again the end result will depend on early or late reduction.

Dislocation of the Wrist. Dislocation of the bones of the wrist are sometimes difficult to reduce. Occasionally a single bone like the semilunar will be dislocated. If not reduced it leaves a serious disability in the form of impaired grip, pain and impaired motion. Even after reduction there is generally a slight residual defect in motion.

Dislocation of the Fingers. Many fingers are disabled because the dislocation is regarded unfortunately as a minor injury. So-called sprains of the finger joints are frequently dislocations. The X-ray will confirm or deny.

Peripheral Nerve Injuries

Prognosis. In the prognosis of peripheral nerve injuries the following factors should be given consideration: the mode of production, the nature and the extent of the lesion and the nature of the treatment.

Consolidation. The evaluation of the end results of peripheral nerve injuries depends first upon the certain knowledge that the condition is permanent and second upon the extent of sensory or motor involvement. This involves the necessity of waiting until we can be assured that regeneration is unlikely. In the event that an operation is performed, sufficient time must elapse until the nerve is healed and regenerated. This varies with different nerves and with different types of lesions.

Specific Nerve Injuries

Brachial Plexus Lesions. These lesions may be total or partial. The majority are of the latter type and are generally classified as *Erb or upper arm type* and *Klumpke or lower arm type*.

The *Erb or upper arm type* is due to a lesion (injury) of the fifth and sixth cervical nerve roots. As a result of this paralysis the following movements are lost: ability to abduct the arm (carry the arm away from the body), ability to rotate the shoulder externally and internally (outwardly and inwardly), to supinate the forearm (to turn the forearm so that the palm of the hand faces upward), to oppose the shoulder blades (that is bring them together), and to adduct the arm (bring it close to the side of the body). There is an extensive atrophy of the shoulder muscles. There is also a diminished sensation on the outer border in the upper arm, forearm and hand corresponding to the area of skin supplied by the fifth and sixth cervical nerves.

Klumpke's paralysis or the lower arm type is due to an involvement of the roots of the eighth cervical and first dorsal nerves. There is a paralysis of all the small muscles of the hand as well as the superficial and deep flexors of the fingers. Pain and sensory disturbances in the ulnar region are not uncommon.

The general prognosis is poor. In total plexus lesions two years should elapse before a final estimate of disability should be made. In these cases the disability in the arm is complete or one hundred per cent.

In partial lesions it is best to rate according to the residual function in the arm and hand as determined by impaired strength and coordination rather than by an arbitrary fixed percentage for each specific lesion, Erb or Klumpke, since these lesions vary too much to make the residual loss of function a fixed quantity. In eighteen cases of the upper arm type the disabilities were from ten to sixty-six per cent. The latter high figure was warranted because of the marked interference with the function of the hand radical.

Suprascapular Nerve. Injury to this nerve causes a paralysis of the supraspinatus and infraspinatus muscles with loss of the power to abduct and rotate the arm. Writing and sewing are particularly impaired by this condition. Disabilities range from ten to twenty per cent.

Subscapular Nerve. The subscapularis muscle, the teres major and latissimus dorsi muscles are involved in injuries to this nerve resulting in impaired movements of shoulder with disabilities from ten to fifteen per cent.

Circumflex Nerve. The circumflex nerve supplies the deltoid muscle, that powerful muscle which covers the shoulder joint and possesses the important power of raising the arm away from the body. The disability ranges from twenty-five to thirty-five per cent. It should be remembered that some of these estimates would be higher but for the fact that many of the functions lost by the paralysis of individual nerves are partially retained through substitution by adjacent sound muscles.

Musculo-cutaneous Nerve. Paralysis of this nerve is accompanied by loss of power of flexion and supination of the forearm, the function of the biceps muscle. The prognosis for recovery is good and at least eight months should expire before a final determination is made. In irremedial paralysis estimates range from thirty-five to fifty per cent of the arm.

Musculo-spiral Nerve. The musculo-spiral nerve is the most frequently injured nerve in the body. It is rather unique in the character of its response to injury, namely a quick and complete paralysis of the extensor muscles of the wrist and fingers causing the characteristic wrist drop. The prognosis is generally excellent. In one hundred twelve cases eighty-eight regained function in eight months, four within twelve months and ten within eighteen months. Of this group, thirty-six patients were operated on, twenty-two to have the nerves relieved of compression and fourteen for the nerve suture on account of laceration.

The extent of permanent disability in the above cases was:

88	No permanent disability
7	10 per cent of the arm
9	25 per cent of the arm
2	33 per cent of the arm
6	66 per cent of the arm

Median Nerve. This nerve responds to injury not only by paralysis but also by loss of sensation in the important areas in the hand which it supplies. More frequently injuries to this nerve cause not a paralysis but an intense irritation which manifests itself in a causalgia or intractable pain in the area of its supply.

The permanent disability resulting from injuries to the median nerve depends to a large extent on the site of the lesion since various branches come off at different levels. The estimates vary widely from fifteen to forty-five per cent.

Ulnar Nerve. Injuries to the ulnar nerve offer the worst prognosis of all the major nerves of the upper extremity. The majority show sensory and trophic changes either alone or in combination with paralysis of the small muscles of the hand with flexion deformity of the last two fingers, producing sometimes a claw hand deformity.

The evaluation of the disability following ulnar nerve injuries depends also on the site of the nerve injury as well as the extent of involvement. One to two years should elapse before a final estimate should be made. Estimates in injuries of the nerve below the elbow vary from fifteen to forty-five per cent. At the elbow estimates range from twenty to forty-five per cent. Above the elbow disabilities range from forty-five to seventy-five per cent.

MISCELLANEOUS INJURIES OF THE UPPER EXTREMITY

Shoulder and Arm

Contusions. By contusions are meant those injuries to the shoulder region that do not cause fracture, nerve or joint injury. There may be subcutaneous (under the skin) collections of blood (hematoma) and some discoloration or swelling. As a rule the temporary disability is short, eight to ten days, and there is no resulting permanent disability. However, in older people prolonged immobilization may leave the patient with stiffness of the shoulder.

Sprains. These injuries, usually due to wrenching of the shoulder, cause no great disablement with proper treatment and early movement. With proper treatment the temporary disability should not last longer than three to four weeks. Occasionally a slight restriction of motion may remain which rarely exceeds five per cent. However if the injury is complicated by peri-arthritis of the shoulder the disability may equal that of more serious injuries.

Peri-arthritis of Shoulder. The most disabling affection of the shoulder with the exception of paralysis is the condition which for the want of a better name has been described as peri-arthritis (inflammation around the joint) of the shoulder. Although the exact

pathology is not clear it is known to occur as a complication of all injuries of the shoulder from contusions to fractures. It is characterized by marked wasting of all the shoulder muscles, by pain and by marked restriction of motion in all directions. A reasonable explanation for the development of this condition is one which holds that it is due to prolonged immobilization with lack of use favoring the formation of adhesions between the muscles, tendons, ligaments and capsule.

Temporary disability is protracted lasting from three to eight months. In the average case the permanent disability is estimated at thirty-three and one-third per cent of the arm.

Rupture of the Supraspinatus Muscle. Rupture of this muscle is a not uncommon injury in persons past middle age. The rupture may be partial or complete. In the latter case surgical repair is necessary. The period of temporary disability and the permanent disability are the same as in peri-arthritis.

Subdeltoid Bursitis. This bursa lies between the supraspinatus tendon and the deltoid muscle. It may be injured, producing an inflammation of the bursal sac with a collection of fluid or effusion. There is a moderate amount of pain with early resolution and complete recovery in the average case.

On the other hand there is an associated condition which is frequently called bursitis but is not actually a bursitis. This is a tendonitis. It is true that the bursa may show some signs of inflammation and produce an effusion but this is secondary to the main process which is going on in the supraspinatus tendon. In this tendon, generally as a result of a slight injury superimposed on a structure already the site of wear and tear, the tissues respond to the injury by an actual degeneration. Chemically this area then saponifies and as a subsequent step calcium is deposited in the saponified material. This lime deposit can be seen in the X-ray and is given a variety of explanations in the evaluation of the pain suffered by the patient. Usually the pain is due to the tension in the tendon plus the tension in the swollen bursa. However lime deposits are frequently found in the shoulders of patients as an incidental finding with no complaint of pain.

These cases with calcification take one of two courses. (1) After a period of temporary disability of three to four weeks the symptoms subside completely and there is no permanent disability. (2)

The condition may become protracted over a period of several months when as a result of inactivity and immobilization atrophy and ensuing peri-arthritis, it leaves a permanent disability of thirty-three and one-third per cent.

Rupture of the Biceps. This is of rare occurrence in young men. It occurs in muscles already the seat of beginning degeneration from excessive use over a long period of time. The disability it causes lies chiefly in the loss of strength. Since the biceps has two heads (or points) of origin and it is usually the long head that is ruptured, the short head still remains to carry on the important function of flexing the elbow. In six cases the permanent disability ranged from ten to twenty-five per cent.

Elbow and Forearm

Sprains. This condition of the elbow joint is quite common. The joint capsule and lateral ligaments may suffer injury. The usual end result in a moderately severe sprain is a permanent impairment of extension of a few degrees which may warrant a disability estimate of five per cent. In examination of the elbow for loss of motion it should be compared with the opposite elbow. Occasionally an apparently normal elbow is seen on such comparison to lack several degrees of motion. This is due to the fact that the elbow was naturally hypermobile.

Olecranon Bursitis. This is a common condition following direct injury to the bursa. The effusion is profuse and returns repeatedly despite aspiration. Excision of the bursa gives the only protection against return of the effusion. There is an occasional loss of a few degrees of motion after operation which warrants an estimate of five per cent of the arm.

Myositis Ossificans. This affection has already been mentioned as a complication of fractures about the elbow. It may also accompany sprains of the elbow or other injuries severe enough to dislodge some bone cells which proliferate and cause this disabling condition.

Ischemic Sclerosis. Although the damage from an ischemic sclerosis is manifested chiefly in the loss of the function of the hand, it may be well to consider it here because the origin of the trouble is in the region of the elbow. That the condition is essentially due to vascular injury with concomitant loss of nutrition supplied by the injured vessels to the muscles is now generally believed to be

the explanation for this phenomenon. Constriction from bandages or because of the position of the elbow may be secondary or aggravating causes.

Eighteen to twenty-four months should be allowed for temporary disability with allowances for permanent disability ranging from fifty to seventy-five per cent.

Wrist

Sprains. These injuries are quite common but must be differentiated from small chip fractures of the styloid processes of the radius and ulna at the wrist. Temporary disability lasts from seven days to a month. Occasionally slight stiffness remains corresponding to a five per cent disability.

Sprains of the carpal joints are more disabling. The X-rays are generally negative for fracture yet the hand is characterized by local thickening and tenderness. The temporary disability is double that of wrist sprain while a residual disability of ten to fifteen per cent frequently remains.

Lacerations. One of the most disabling injuries results from the laceration of the volar (palmar) aspect of the wrist. Because of the relatively superficial position of the tendons and nerves to the hand they are usually severed. The function of the tendons and nerves must be tested even in apparently superficial cuts. Again disability is severe after repair or severed tendons due to adhesions, cross union and neuroma formation in nerves involved in scar.

Stenosing Tenosynovitis. This occurs at the radial styloid process due to chronic irritation from repetitive movements. The tendon sheath is thickened, thus choking the tendon and preventing smooth and automatic movement of the tendon in the sheath. Incision of the sheath releases the obstruction generally with complete recovery.

Hand and Fingers

Wounds. These are significant in that the most trivial wound may be the cause of serious disability. The most important complication of a wound is infection. The hands of the average person are the site of numerous superficial abrasions that go unnoticed until pain and local disability call attention to the advent of an infection. The end result of these infections can be very serious. This is especially true where treatment is delayed or inadequate or

improper surgery is performed. The sloughing of tendons, the resulting contractures and loss of power of fingers, the occurrence of osteomyelitis all contribute to the prolonged period of temporary incapacity and to the permanent disability that follows these infections.

Tendon Injuries. The most serious injury to tendon is severance. If left unrepaired a permanent functional disability follows, which corresponds to the loss of motion to that finger. The prognosis of injuries to the flexor tendons even after repair is not as good as that of the extensor tendons on the back of the hand.

Ganglia. These are cysts attached to tendons filled with a mucinous substance. Though they may occur without direct injury, indirect injury can cause them. Aspiration and pressure in the mild cases and excision in the recurrent cases yield satisfactory functional results, there being little if any disability.

Foreign Bodies. Foreign bodies may be inbedded in the hand without giving any trouble or incapacity. In that case no permanent disability should be allowed. However, when the foreign body is near a small cutaneous nerve or in a pressure bearing area, incapacity should be recognized. The disabling effect is not one that involves strength or motion. As the result of slight pain or fear of pain there is some retardation in the carrying out of quick and dexterous movements. As a rule when disability exists it is minor, rarely exceeding five per cent of the hand.

Nerve Injuries. With the exception of the ulnar nerve, these injuries have a good prognosis. The trophic changes seen in ulnar lesions higher up are also present in palmar lesions. These are characterized by ulcers that fail to heal due to the absence of trophic (nervous control over local nutrition) impulses to that area.

Dupuytren's Contracture. This is due to a slow but progressive contracture of the palmar fascia involving chiefly the last two fingers and ultimately rendering them useless. Trauma plays no part in either initiating or aggravating the condition. The writer supports the nerve origin theory since the onset, course, development and regional character of the lesion are analogous to similar conditions such as claw foot which is known to follow degenerative changes in the central nervous system. The condition has been never observed in Negroes.

Mallet Finger. Injury to the insertion of the extensor tendon at the base of the terminal phalanx causes a typical deformity which has been given the name of mallet, hammer or drop finger. There is a permanent loss of extension in the last phalanx which is held in a flexed position. The average disability is twenty-five per cent of the finger.

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