# Bunnell's Surgery of the Hand

Joseph H. Boyes

Fourth Edition

# Bunnell's SURGERY OF THE HAND

*Revised by*


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# Preface to the Fourth Edition

Sterling Bunnell designed this book primarily to treat of reconstruction, with added sections for other necessary aspects such as infections, fractures and tumors and such personal interests as phylogeny and comparative anatomy of the hand. He assumed that the reader had adequate knowledge of the basic anatomy and the surgical principles and felt that hand surgery should be a composite of plastic, orthopedic and neurologic experience. The original edition was illustrated from his extensive experience. Subsequent editions included the reports of many others, particularly of the casualties of World War II.

This fourth edition is a complete revision, designed along the original lines, stressing principles over details and reconstructive rather than reparative surgery. Purposeful repetitions in previous editions have been deleted, and items of only sectional interest, such as local governmental regulations of disability allowances, have been discarded.

The terminology used in the previous editions describing the finger joints as proximal, middle and distal rather than the cumbersome anatomic terms of metacarpophalangeal and interphalangeal is still preferred. The names of the carpal bones and some of the forearm and hand muscles now conform to the accepted P.N.A. system.

The original plan of treating the reconstructive problems of the various tissue systems—skin, bones, joints, nerves and tendons—is followed again, but a new arrangement of chapters leads the reader through the comparative anatomy to embryology and congenital deformities before discussing the reconstruction of the systems.

New material has been added on splints, the surgery of the intrinsic muscles, the neurovascular pedicle transfer of tissues, tendon transfers, reconstruction of the thumb and trophic and vascular lesions. The principles of the surgical treatment of rheumatoid arthritis and gout are covered in the chapter on Joints.

A bibliography for each chapter lists articles considered worth while for further reading. An index has been provided which will help to locate the principal topics rather than catch words. Where a subject such as tendon repair is treated both from reconstructive and reparative standpoints, the text contains the necessary cross reference.

As in all endeavors, much help comes from others. Mrs. Bunnell has made many notes and records available. Dr. L. D. Howard has clarified questions on the use of some procedures described in the latest edition. The material in the chapter on tumors, which he originally provided, has been edited and condensed with his permission.

Thanks are extended to colleagues who provided illustrative material, especially to William H. Frackelton, M.D., Walter C. Graham, M.D., J. William Littler, M.D., Daniel C. Riordan, M.D., R. R. Schreiber, M.D., and L. Ramsey Straub, M.D. My associate, C. R. Ashworth, M.D., arranged the bibliography.

The typing of the manuscript by Miss Berle Draper has been done as a measure of the respect and the esteem which she and the revisor shared for Sterling Bunnell by reason of their previous experience in working for him.

JOSEPH H. BOYES, M.D.

# Preface to the First Edition

We are now in a mechanized age, which means that millions of hands will be injured. It might be called the Age of Trauma. With the speed-up of industry and with mechanized warfare the manual worker will, from the very nature of his work, injure his hands. Hands lead the list of industrial accidents and are responsible for a large portion of compensation expense. From a social standpoint the functioning of this valued member is of vital importance to the manual worker for his very livelihood.

From an evolutionary aspect, our hands when we became bipeds were relieved from the duty of locomotion and were then free to develop into more useful instruments. By brains and hands man excelled over all other species; for other animals had as weapons only hoofs, claws, or teeth, while the hand of man could grasp any weapon. The brain developed the hand, but it is also true that in each one of us many of our mental processes have developed from the feeling and movement of our hands. In the case of the brilliant Helen Keller, both deaf and blind, her whole life was opened up through her hands. The special development of the human hand is largely responsible for the great handicraft of man.

The hand is so intimately rooted into our lives, thoughts, and expressions that it has become a part of our language, as evidenced by the following: handle, handy, secondhand, to give the hand in marriage, all hands on deck, rule with a strong hand, at hand, on hand. From the Latin *manus* are derived manage, management, mandate, manipulate, maintain, manner, manuscript, manufacture; from the Greek *cheiro* come the French word *chirurgie* and our English surgery.

Although the hand is composed mainly of tough material, it also includes exact machinery of much refinement and tissues of great delicacy and specialization. Such a mechanism is readily wrecked by trauma and infection, and it is little wonder that hands mangled by trauma, or those infiltrated and gutted by infection, later present difficult problems in reconstruction. After tendons and nerves have sloughed and the storm of infection is over all of the tissues contract, resulting in flexion contractures, and the movable parts become bound with cicatrix into a congealed hand. Much of this disability may be spared by correct early treatment of infections and injuries.

Malformation, injury, and infection swell the ever-coming stream of crippled hands needing repair. To recondition these members successfully is difficult. Surgical reconstruction of the hand requires special careful technic to minimize adhesion formation which is so prone to bind together the nicely adjusted moveable parts. It is a composite problem requiring the correlation of the various specialties—orthopedics, plastic and neurologic surgery—the knowledge of any one of which alone is inadequate for repairing the hand. Trauma involves all types of tissue, irrespective of the artificial divisions of our specialties. Usually in the same traumatized limb with flexion contracture, injury to tendons, bones, joints, and nerves, we must combine plastic, orthopedic, and neurologic surgery. As the problem is composite, the surgeon must also be. It is impractical for three specialists to work together or in series. There is no shortcut. The surgeon must face the situation and equip himself to handle any and all of the tissues in a limb.

In hand surgery the structures encountered are the same, though in miniature, as found elsewhere, so the same principles and problems met with here apply throughout the body. In reconstructing hands, though the cosmetics are important, the practical object is to restore enough function to the limb to allow the patient to return to wage earning and self-support.

Primarily this book was designed to treat reconstruction alone; but it has been expanded to include a little of other aspects that seemed necessary, and also along some lines where interest beckoned. An attempt has been made to keep it concise for the sake of the reader's time. Main principles have been stressed over details, as any able surgeon should improvise his own methods of operating. There are some purposeful repetitions for emphasis where the subject applies in different chapters, lest only that part be read at the time. An effort has been made not to overburden the text with historical references but merely to express the facts on a working basis. Knowledge develops from the thousands who precede, and to these we owe our gratitude. As many as practical are mentioned in the text and bibliography, but there are many more.

The terms metacarpophalangeal, proximal interphalangeal, and distal interphalangeal are too ponderous, and first, second, and third joints are ambiguous as counting may start from either end. Therefore, the terms proximal, middle, and distal joints or segments are used for fingers and proximal and distal for thumb. Also, to avoid ambiguity the digits are designated by name rather than by number. Angulating is used in the sense of describing an arc with the distal fragment.

Throughout the world in peacetime were myriads of hands in need of repair. The war is adding such an appalling number of crippled hands, depriving men of their earning power, that surgeons now have had thrust upon them this work of reconstruction. It is with a desire to aid in this work of restoration that this book is written.

I wish to express my appreciation to my colleagues, Major L. D. Howard, Jr., M.C., A.U.S., and Captain Donald R. Pratt, MC., A.U.S., for their cooperation and help in the surgery of hands and in the development of the use of removable stainless steel wire. To my associate, Doctor Howard, I am especially grateful for his contribution, the chapter on Tumors of the Hand.

Deep appreciation I feel for my wife, Elizabeth Bunnell, who with steadfast, wholehearted cooperation prepared the major portion of the manuscript. I wish also to acknowledge my gratitude to Mrs. Helen Loran for her valued help in this work, to Mrs. Douglas Young for her part in the photography, and to Miss Margot Beggs for her editorial work.

Grateful acknowledgment is due Mr. Ralph Sweet and Mrs. Rosebud Preddy for many of the illustrations.

I wish to acknowledge with thanks the permission received from the following journals to reproduce in part my articles published in them: The American Journal of Surgery, California and Western Medicine, Industrial Medicine, Journal of Bone and Joint Surgery, Surgery, Gynecology and Obstetrics, and Rocky Mountain Medical Journal.

Last but not least I feel a debt of gratitude to my publishers, J. B. Lippincott Company, who induced me to write this book and who have been splendidly cooperative throughout.

STERLING BUNNELL, M.D.

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Chapter 1

# The Normal Hand

The hand is an organ of grasp as well as an organ of sensation and expression. By the use of our hands we learn shape, size and texture of objects and then combine this information with impressions from other senses to build in our brain the knowledge of our environment. We use our hands not only as tools for grasping, pinching and pushing, but with our brain directing the hands we manufacture tools for special purposes. Lower animals have specialized claws and hooves, whereas man can make and grasp any weapon. Our hands become extensions of the intellect, for by hand movements the dumb converse, with the specialized fingertips the blind read; and through the written word we learn from the past and transmit to the future. The normal hand is a pentadactylate mechanism of basic design; its finer motions and sensibility have been developed over the ages on the primitive amphibian pattern. It is not self-sufficient but needs the control of higher centers. It is the brain that sets man apart, but the brain acting through the mechanism of the hand has helped him to become the master of the universe.

To reconstruct a damaged hand, we must know the normal. Surgery of the hand is that of the upper limb, for though the hand's mechanical base may be at the elbow, its dynamic origin is in the brain. All movements of the shoulder, the elbow and the forearm are made to place the hand in a proper position for function. These parts may be normal, but without a mobile sentient hand they are of little use. Conversely, a normal hand without a stable elbow and shoulder is little more than a feeble helper.

The right hand is usually dominant; the arrangements of objects in the physical world, as in the turning of screws, doorknobs and bolts being such as to utilize supination, which is stronger than pronation. Left-handedness varies between 10 and 30 per cent of the population and is reportedly somewhat higher in young children and in some areas such as England. True ambidexterity or bilaterality is rare. Dominance is easily transferred in the young, after injury or paralytic disease.

## SKIN AND CREASES

The skin on the volar surface of palm and fingers is tough and thick to stand wear. It covers a thick pad of fat with many fibrous septa. It is not very mobile and allows little plastic maneuvering. A system of creases, where the skin is adherent to the deeper layers, allows for closing of the hand without bunching up in folds.

On the dorsum, the skin is thin, soft and yielding, and its subcutaneous layer is loose and pliable. Covering a convex surface, it is flexible to allow for closure of the fist. Minute wrinkles at right angles to the line of pull take the place of creases as on the volar surface, and special redundancies over the finger joints allow the covering skin to stretch over these areas in maximum flexion. Over the thenar eminence a combination of longitudinal and transverse wrinkles allows the infinite combination of movements of this digit.

The palmar skin is without pigment and hair, but well supplied with sweat glands. On the dorsum, hair-bearing skin is present except over the distal and sometimes the middle segments.

Two flexor creases overlie the middle finger joint; but only one, and it slightly proximal, marks the level of the distal finger joint. A single crease in the proximal segment of the finger identifies the distal edge of the palm or web, which extends volarward to the middle third of the proximal phalanx. On the dorsum, the base of the cleft lies more proximal, and for cosmetic reasons this sloping appearance of the web should be reconstructed in syndactylism operations.

Two creases are normally seen in the palm: the proximal or thenar crease for use of the thumb; and the distal, running from the index middle finger cleft to the ulnar border, for use of the ulnar 3 fingers. A composite crease, the line extending from the radial end of thenar to the ulnar end of distal crease is often called the midpalmar crease. It represents the level of proximal finger joint action. Since the fingertips normally flex to touch this crease, a measurement of the distance which a finger pulp lacks of touching the crease can be used to record impaired finger flexion.

The thenar crease allows for the wide range of thumb motion. Thus longitudinal wrinkles for forward motion of opposition and reposition are present as well as transverse wrinkles at the base for flexion. The thumb index web is loose and pliable and has alternating oblique folds as the thumb is moved away from or toward the plane of the palm. Transverse folds appear as the thumb approaches the index finger.

On each finger the flexor creases divide the subcutaneous fat into 3 pads. Each crease extends only to the midlateral line. The skin is attached directly to the flexor tendon sheath at the level of the middle crease, and puncture wounds in this area enter directly into the sheath space.

The nails are specialized ectodermal organs for scratching, pinching and picking up small objects. They give added stability to the pulp. The pulps of the fingers contain a large number of sensory receptors. Skin grafts for replacement of pulp skin never have the fine quality of sensibility or stereognosis that is present in normal skin.

The fingernails require about 4 months to grow their length and may show transverse grooves partly down the nail from an illness within the last 4 months. At their sides and bases the nails curve more sharply, so this must be kept in mind in incising for paronychia. The lunula corresponds to what is practically a potential space, like an ungual bursa; the cellular attachment there is so slight that the space may readily fill with blood or pus. The nails overlie the distal phalanges intimately enough to give firm support to the finger pulp.

Fig. 1. Normal flexion creases of the palm. A thenar crease representing the level of motion of the thumb and an ulnar crease for motion of the middle, the ring and the little fingers. Motion of all fingers results in a combination or *distal palmar crease*. Lack of flexion of the pulp of a finger to this crease is a measurement used to record finger flexion.

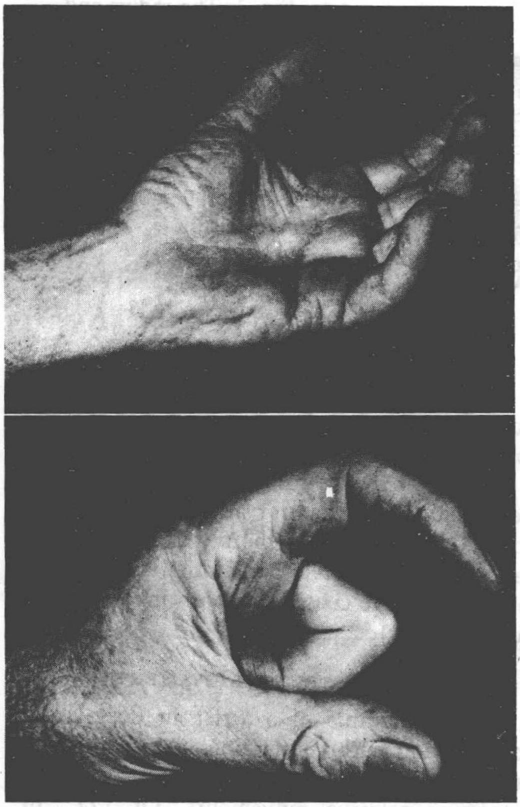

FIG. 2. Arches of the hand and flexor creases of the finger. (*Top*) The carpal and and the metacarpal transverse arches. As the fingers flex, their tips remain on same level because of the concave plane of the metacarpal heads. (*Bottom*) The flexor creases in a finger. Only the middle flexion crease lies directly over a joint, the proximal crease is at the level of the web, and the distal crease is well cephalad to the distal joint. When the finger is flexed, the creases are almost at right angles. Note the dorsal termination of the middle flexion crease, the optimum site for the midlateral skin incision.

## MOVEMENTS OF THE ARM

A series of joints from shoulder to fingers give the hand a most unusual versatility. By a combination of the ball-and-socket shoulder, the elbow hinge and the rotary motion of the forearm, the palm can be placed to cover any part of the body except between the scapulae. The hand can push away or pull to the body from any of these positions.

The shoulder has a large range of motion angulating and rotating widely. Shoulder motions are complex, involving scapular movements on the chest wall as well as motion in the scapulohumeral joint. The clavicle acts as a strut for stability.

The elbow hinges in one plane until the last third of extension when the forearm angulates outward to form the carrying angle.

The 2 radio-ulnar joints furnish pronation and supination of the forearm through an arc of 120° to 150°. Rotation of the forearm is measured with the elbow at right-angle flexion, thus blocking rotary motions of the humerus. With the ulna fixed, the radius rotates around the axis of the distal ulna; but in pronation and supination a combination motion takes place, the ulna deviating opposite to the radius, so that the axis of motion, as in using a screwdriver, is more in line with the distal radius and the 2nd metacarpal.

Each radio-ulnar joint has the same amount of rotary motion. The proximal joint is a true swivel with an orbicular ligament, but at the distal joint the broad end of the radius rotates around the fixed ulna. On the head of the ulna opposite the styloid process is the articular facet comprising about two thirds of the surface. There are 3 ligaments at the distal ulna. One is a strong pivot ligament from styloid process to triquetrum; a second is a loose cufflike ligament around the radio-ulnar articulation, which clasps about the margins of the opposing facets. This ligament, as the radius rotates, tightens in its dorsal part on pronation and in its volar part on supination. Its volar portion is most important in preventing subluxation of the ulna. The third ligament is the articular disk, attached to the radius and pivoting on its attachment to the styloid process of the ulna.

## MOVEMENTS OF THE WRIST

The wrist can angulate in any direction and by a combination can circumduct as a universal joint. Palmar flexion is normally greater than dorsiflexion, and ulnar flexion is usually double that of radial flexion. Lateral motions are greatest with the wrist straight or in slight palmar flexion. In normal use, the axis of motion in the wrist is not in a true dorsal volar direction but more from dorsoradial to ulnar volar. The strongest wrist

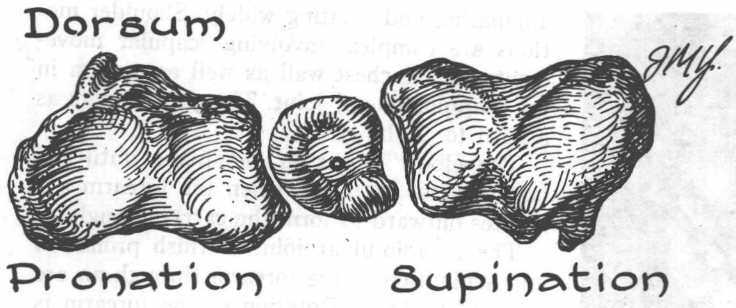


FIG. 3. The radius and the ulna seen from the wrist to show relations in pronation and supination. If the ulna is fixed, the radius performs an arc of slightly less than 180° about the center axis 0.

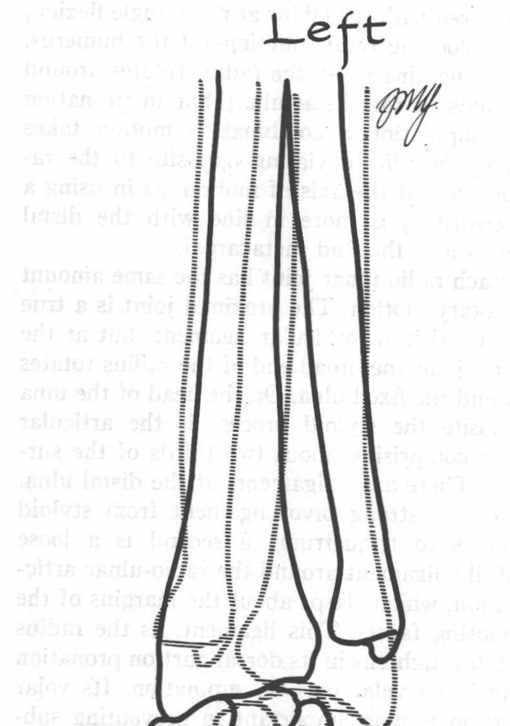


FIG. 4. When the forearm is pronated and supinated, as in using a screwdriver, the motion involves not only a rotation of radius around ulna but also a lateral shifting of the ulna. The longitudinal axis for this total action is now near the ulnar border of the distal radius. (Adapted from Capener, N., J. Bone Joint Surg. *38B*:128, 1956)

motors are the flexor carpi ulnaris and the opposing 2 radial wrist extensors.

The center for lateral motions appears to be more distal than that for anteroposterior motions. Detailed studies show wrist motions to be most intricate. Neither motion takes place through a single center, for both involve more than one joint.

### Anteroposterior Movements

Roentgenograms of a wrist in dorsal and volar flexion with center lines drawn through radius, capitate and lunate were measured to determine relative movements. Of 122° of movement between capitate and radius, 66° or 54 per cent took place between the lunate and the radius; thus the radiocarpal joint provides about one fifth more motion in this plane than the midcarpal joint.

### Lateral Movement

This movement is complex. The capitate moves with the hand and, as measured on the line of the radius, about 45° of motion takes place. Of this, about two thirds is ulnarward of the neutral position. However, the capitate in making this motion also moves in a dorsal volar direction, rocking on the concave surface of the lunate. In turn, the lunate rotates on the articular surface of the radius. In ulnar flexion the scaphoid is pushed radialward by the capitate and makes a dorsal revolution. In radial flexion the trapezium moving with the thumb ray pushes the scaphoid, causing it to make a volar revolution and a simultaneous shift ulnarward. Strict radio-ulnar motion is impossible at the radio-carpal joint because of the double curvature of the end of the radius; therefore, the functional midcarpal joint runs out the cleft between the thumb and the index.

FIG. 5. In anteroposterior motion of the wrist, more motion occurs at the radiocarpal than the midcarpal joints. The axes of the capitate, the lunate and the radius are shown.

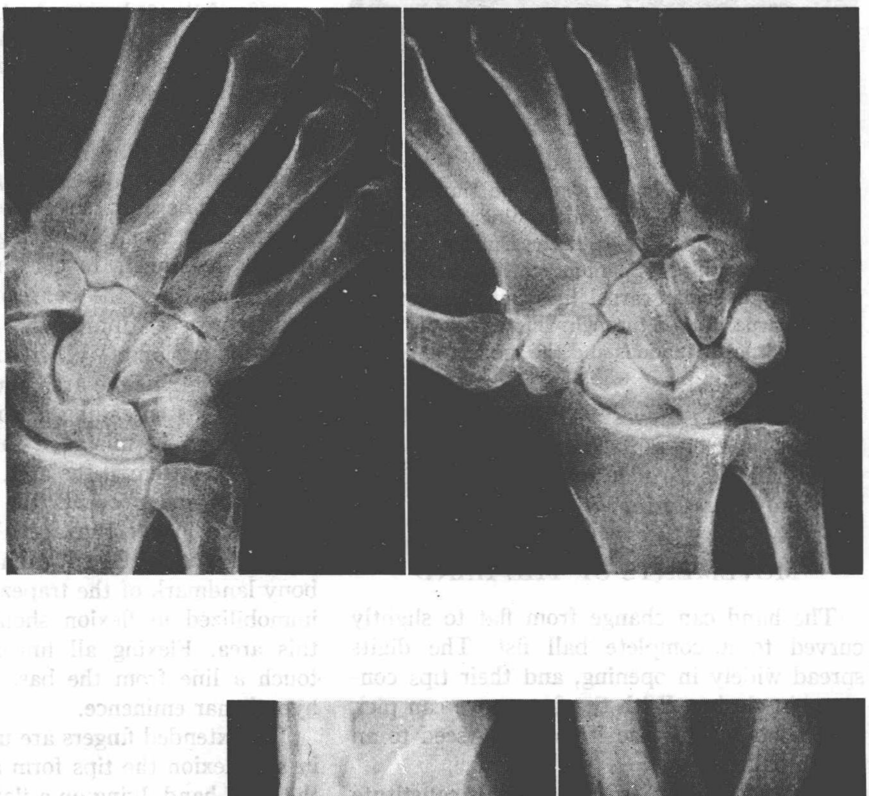

FIG. 6. In lateral movements of the hand at the wrist joint, the capitate moves with the hand on the proximal carpal row, and the proximal row shifts on the radius. The thumb ray, the trapezium and the scaphoid form a separate unit, the rotary motion of the latter being volar in radial flexion and dorsal in ulnar flexion.

FIG. 7. Motions in the carpus on lateral movements. (*Left*) Ulnar deviation. (*Right*) Radial deviation. The lunate rotates volarward in the cup of the ulnar half of the radiocarpal concavity, while the scaphoid rotates volarward when the wrist is deviated radially.

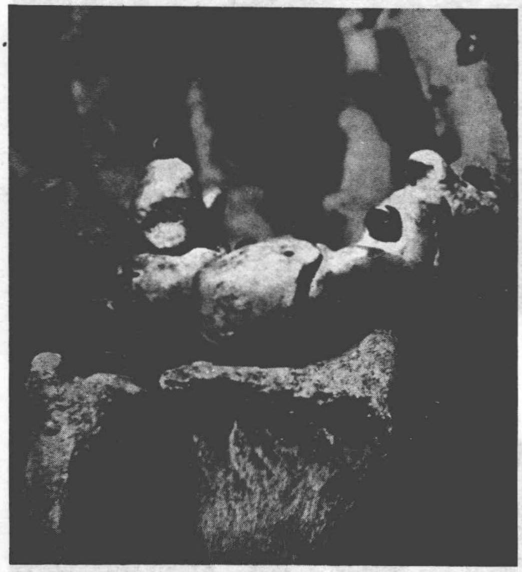

FIG. 8. Carpal arch and tunnel. On the radial side two bony ridges, the trapezium and the scaphoid, and on the ulnar side, the pisiform and the hook of the hamate, form the bony pillars. Spanning the roof of the canal, the volar carpal ligament completes the carpal tunnel through which pass all the digital flexor tendons and the median nerve.

FIG. 9. Tunnel view of wrist, demonstrating borders of carpal canal. Such views can be obtained by directing the rays along the axis of the 3rd metacarpal, while the volar aspect of the wrist rests on the film holder, and the wrist is dorsiflexed about 60°. (Hart, V. L.: J. Bone Joint Surg. *23*:948)

The thumb ray moves with the proximal carpal row, and on radial flexion the tip of the thumb reaches ½ inch farther down the index than on ulnar flexion.

## MOVEMENTS OF THE HAND

The hand can change from flat to slightly curved to a complete ball fist. The digits spread widely in opening, and their tips converge in closing. With the fingers we can pick up objects of any size from a tiny seed to an 8-inch ball.

The 2nd and the 3rd metacarpals constitute the fixed part or keystone of the arching hand. The index metacarpal is firmly fixed on the carpus, and the middle metacarpal is almost as solid. On the radial side the thumb moves freely through a wide arc, and on the ulnar side the ring and the little metacarpals have considerable mobility on the hamate.

### Arches of the Hand

There are 2 transverse arches: one at the metacarpal heads, the other at the distal carpal row. The metacarpal arch is flexible, being increased by action of the thenar and the hypothenar muscle groups pulling the outside rays forward. The arch gives strength to the hand in grasping round or irregular objects and causes the fingers to converge in flexion. As the fingers flex, the curve of the metacarpal arch increases, tipping the axes of the proximal finger joints. When opening the hand the flattening of the arch causes the fingers to spread. This spreading action of the long extensors may be mistaken for intrinsic muscle activity. Flattening the arch as by pressure or holding a rod prevents the tipping, and the fingers no longer converge. When the fingers are individually flexed, each tip points to the bony landmark of the trapezial ridge. A finger immobilized in flexion should be pointed to this area. Flexing all fingers together, they touch a line from the base of the thumb to hypothenar eminence.

The extended fingers are unequal in length; in semiflexion the tips form a straight line. If the open hand, lying on a flat surface, is gradually closed to make a fist, the tips of all the fingers will stay aligned on the same plane through most of the act, though at the end of the middle finger leads to touch the palm. In full extension the ring finger is usually next in length to the middle finger, but in many individuals the index finger is equal to or longer than the ring finger.

### Mechanics of Finger Motions

The finger joints are sliding joints like the knee, so that in flexion the prominence of the joint is the distal condyle of the proximal bone of that joint. The proximal joints flex 70° to 90°; the middle joints 105° to 115°; and the distal joints 45° to 90°.

In extension all finger joints have some lateral motion which is lost in flexion. Lateral stability in the flexed position provides firmer grasp. This mechanism is most noticeable in the proximal joints and is due to the shape of the metacarpal heads and the disposition of the collateral ligaments. In the dorsal volar plane the metacarpal heads are narrow on the dorsum, the articulating surface when the proximal phalanx is in extension. Volarly, the metacarpal head is much wider and has a broad area to articulate with the phalanx. The obliquely placed collateral ligaments extending from dorsal aspect of metacarpal to volar aspect of phalanx allow considerable play laterally when the phalanx slides on the narrow metacarpal head; but when the joint is flexed, their direction is now that of a true collateral ligament, and the joint is laterally stable. More motion takes place ulnarward than radialward, especially in the index proximal joint. Ulnar deviation is accompanied by exorotation, and radial deviation by endorotation of the phalanx. The collateral ligaments vary in size and in points of intersection. On the index and the middle fingers the radial ligament is larger and more oblique than the ulnar collateral ligament, whereas in the ring and the little fingers they are more symmetric, more oblique and less well developed. In all

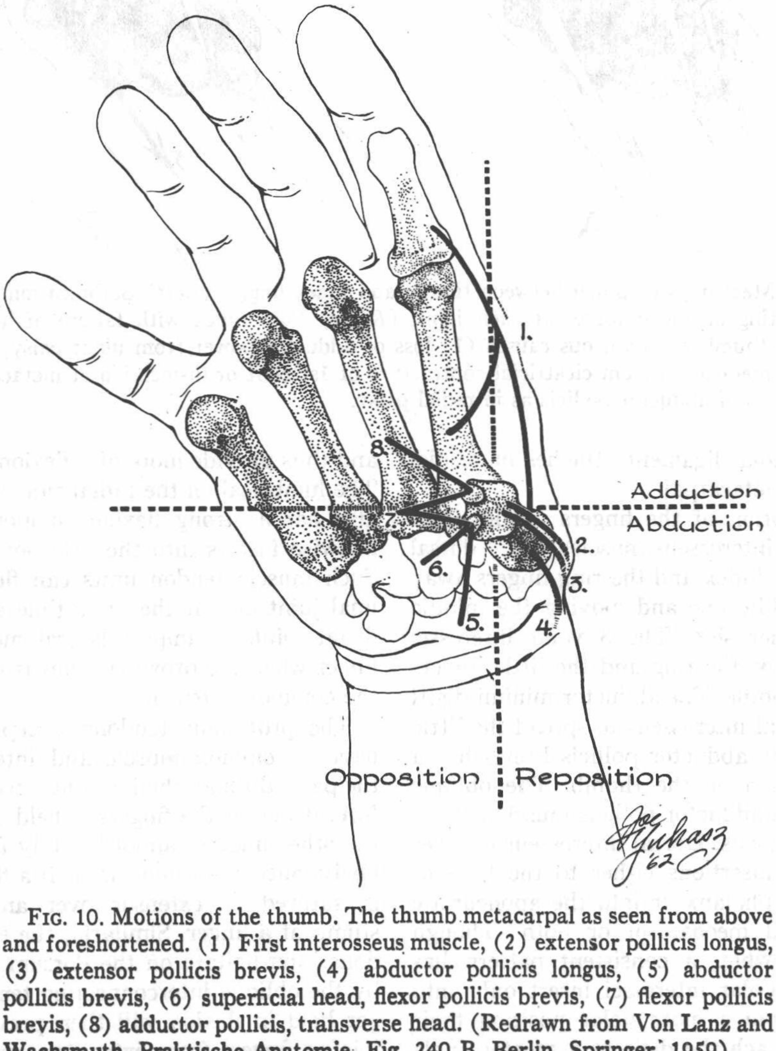


**Fig. 10. Motions of the thumb. The thumb metacarpal as seen from above and foreshortened. (1) First interosseus muscle, (2) extensor pollicis longus, (3) extensor pollicis brevis, (4) abductor pollicis longus, (5) abductor pollicis brevis, (6) superficial head, flexor pollicis brevis, (7) flexor pollicis brevis, (8) adductor pollicis, transverse head. (Redrawn from Von Lanz and Wachsmuth, Praktische Anatomie, Fig. 240 B, Berlin, Springer, 1959)**