Functional and Surgical
Anatomy of the Hand

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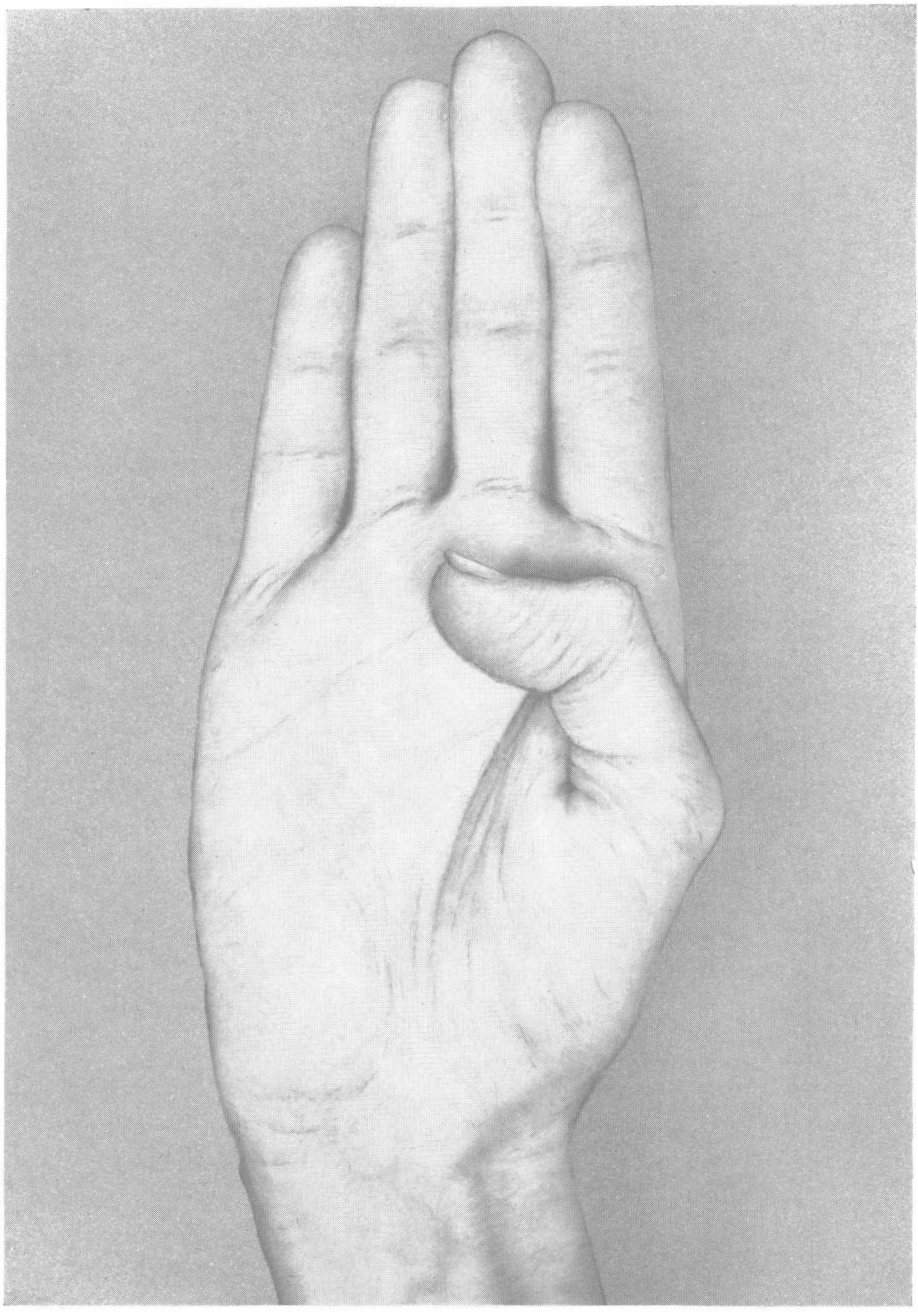

Dedicated to the memory of my wife, Roberta Allen, whose affection, inspiration and self-sacrificing devotion were responsible for this study.

To her able and guiding hand.

"Qu'ils n'oublient jamais que sans anatomie il n'y a point de physiologie, point de chirurgie, point de médecine."

J. CRUVEILHIER
Anatomie descriptive, 1834

Introduction

The literature abounds in descriptions of structure and function of the hand. It would appear that the available descriptions are sufficient and that no additional information is required. This impression is erased when the hand surgeon and the hand anatomist are confronted with special problems.

Following World Wars I and II, valuable and instructive studies were made and published. They were based on the abundant material offered by the destructive power of modern weapons applied to the bones and the soft tissues of the upper extremity. The analysis of this material required so much time and attention that observations made by early investigators were not always consulted. Generally, the early anatomists and physiologists understood very well the function of the hand and possessed amazing knowledge of structural detail. Albinus, Winslow, Cloquet and, even earlier, Columbus, Fallopius and many others understood the action of the extensor digitorum communis, the lumbricals and the interrosei, as well as the flexors of the fingers. In the nineteenth century, Gruber, Thompson and others made the most extensive studies of nerve variations, the full importance of which was appreciated only recently. The information obtained by the great anatomists of the eighteenth and the nineteenth centuries, which is not known generally, could be used profitably at present. In 1867, Duchenne, of Boulogne (France), described completely and comprehensively, in a way probably not surpassed by any other observer, the normal and the abnormal functions of the hand. He also placed his description in a proper historical perspective. But his work was overlooked, and much labor was spent, and is being spent, by other investigators who were not, and are not, aware of the observations made by him. The extensive new material and the surgical and the neurologic experiences accumulated since Duchenne's original publication require further study and more precision in the description of the structure of the hand and understanding of the intricacies of its mechanism.

Stimulated by early acquaintance with the work of classical anatomists and by personal experiences in the surgery of the hand, the author collected useful material in the anatomic laboratory over a period of years. Personal studies were made of anatomic structures, and electric stimulation was applied to the muscles of the hand directly during surgical procedures and indirectly. Electric stimulation of muscles of the rhesus monkey also was produced under appropriate conditions. Several gorilla, chimpanzee, rhesus monkey and baboon hands were dissected. Studies were made by the author on the fasciae of the hand, the embryology of the hand, the tendinous apparatus of the fingers and surgical approaches. Correlation of structure and function was investigated.

There is a general tendency to curtail progressively the time allotted to the teaching of anatomy in the medical schools, but the need for anatomy is greater than ever. It is essential in surgery, where an adequate knowledge of structure could have eliminated inadequate operations performed in the past and those still being performed. Its need in the study of locomotion, rehabilitation, neurologic interpretation and internal medicine, in spite of important

strides in biochemistry, biophysics and so forth, should be obvious even to the ignorant.

In the particular instance of the hand, it was considered that the student, the anatomist and the surgeon needed a unified text with descriptions combining structural detail with precise function. Such unification is of practical importance, especially if combined with principles of surgical anatomy. The surgical anatomy should include the description of approaches to various parts, points of repair, possible errors, illustrative procedures and orientation in case of variations.

To obtain all possible facts and to make this book useful, it was necessary to resort to other fields. In the embryologic development of the hand, some comparative anatomic studies were added to bring out such or other detail for understanding of function or structure. Multiple dissections of human hands were necessary to show the most frequent patterns. It was necessary to consider the variations which occur in the hands and to place them in definite groups to grasp their significance and to help the surgeon to meet these variations with comprehension. Comparative anatomic studies were of great help, as they revealed functional relationships of certain structures, offering opportunities equal to planned experiments, because preservation or elimination of structures with known function in different species frequently permits deductions as to the actual significance of variations in the human hand.

The anatomic structures in this book are described from the viewpoint only of function and surgery. Conventional descriptive patterns of anatomy are not followed. Pathology, diagnostic methods and detailed surgical technics are not given, except to clarify an illustration.

The description of anatomic structures in textbooks does not mention the age of the subject. It considers a hypothetical man of average age. The hands of an old person, a child or an adult between 25 and 35 years of age present obvious differences.

With age, some of the finer structures of the fingers and the motor apparatus, especially round the joints, undergo changes that produce limitations of use similar to limitation produced by injury. The fine adjusting mechanism between the flexor and the extensor apparatus is disturbed easily by the slightest injury and loses some of its function at any age, except in the very young. Interference with the adjusting mechanism induced by aging or by inflammatory or metabolic processes is not dissimilar to postoperative fibrosis. Therefore, it is essential to indicate, when possible, at least the difference due to age.

The function and the anatomy of the hand cannot be separated from the function of the forearm or the arm. The limitations of this study to the hand are arbitrary.

References to comparative anatomy are made only to explain function or understand structure. The author does not contemplate adding material to the discussion of man's relation to other zoologic groups.

It is impossible to separate function of the hand from the central nervous system, but this represents a special field, somewhat outside the immediate need of the surgeon and the functional anatomist, for whom this book is intended primarily.

It was not intended to create an encyclopedia of the hand. This will explain the absence of emphasis on certain subjects which were not studied especially as, for instance, the lymphatic circulation.

The book is illustrated profusely. A few illustrations were obtained from the collections of the Department of Anatomy of the College of Physicians and Surgeons (Columbia University), and their source has been indicated. Aside from these, all the illustrations are original. They were drawn from multiple dissections made by the author and are being published now for the first time.

An attempt has been made to eliminate any misconceptions, and proper credit has been given to the original investigators.

The history of human civilization is replete with special studies of the hand. The expressions, the activities and the configuration of the hand were a constant source of inquiry and inspiration not only to scientists but also to artists, philosophers, men of religion and mystics. In the enormous literature of the past and the present on the subject of the hand, the most curious information can be found alongside rational descriptions. *The Structure, Uses and Abuses of the Hand,* written by William A. Alcott, M.D., and published by the Massachusetts Sabbath School Society of Boston in 1856, may serve as an example. It contains curious advice intermixed with elementary anatomic facts. Although not directly related to our subject, it is of interest to quote one of the many statements in this small book:

> Among the parts of the human system to which the hand should *seldom if ever be applied,* except, *perhaps,* to wash them, are the hair, ears, nose, the hollow of the shoulder, knee and hip, the toes and soles of the feet.

This was "sound" advice by a physician and was given not very long ago. Obviously, the advice was not given for the enlightenment of other physicians. The reference is mentioned as an illustration of approach to the study of the hand. It certainly cannot be compared with a famous book, written also in the nineteenth century but many years earlier by the brilliant Charles Bell, *The Hand, Its Mechanism and Vital Endowments as Evincing Design.*

Contrary to custom, the author is not adding a historical survey on the subject of functional and surgical anatomy. Such a study would be profitable and would place the information which we now possess in proper relationship to the scientific acquisitions of the past, but it would be out of bounds in a practical book on surgical and functional anatomy. However, it may be of interest to mention that this subject was treated with great perspicacity even in the beginning of our era. Galen (A.D. 131-201) devoted a large part of *De usu partium* to the subject of the anatomy and the physiology of the hand. In Daremberg's French translation, eighty-seven pages of very important, in every sense up-to-date, material are devoted to the hand.

As mentioned previously, no contribution is made to the interrelation of the mechanics of the hand to the motor and the sensory systems of the central nervous apparatus. The more remote subjects of psychological and psychiatric influences on the hand are not touched upon. However, this field is of great interest.

The *Essai sur la psychologie de la main,* written by N. Vashide and published in 1909, deserves special interest as an attempt to unify function with complexities of "motor image" from the lofty viewpoints of philosophy and psychology.

Attempts to describe firmly established changes in the configuration and the surface creases of the hands of normal and abnormal individuals were made in a book, *The Hand in Psychological Diagnosis,* by Charlotte Wolff, which was published recently. This type of research requires greater amplification. Special training, not possessed by the average surgeon, is the necessary attribute for such studies. These studies could be of great value in the chapters on function of the hand, and in the future they may transcend the morphologic description and the contemporary approach to the immediate mechanisms of hand function.

Congenital deformities are not included in the description because, in contrast with variations which belong to the domain of the anatomist, the congenital deformities fall into the classification of malformations or, perhaps, embryologic arrest. Their surgical management presents special problems that require an individual approach, depending on the type of deformity, age and other factors.

A complete survey of the subject was made in Denmark recently by A. Birch-Jensen. Recently, O'Rahilly, of Wayne University, published a most interesting study on the morphologic patterns in limb deficiencies and duplications. A. Barsky made

an enlightening study of the surgical problems connected with deformities of the hand.

With due apologies for the many omissions, it is hoped that *Functional and Surgical Anatomy of the Hand* will be of help to the orthopedic, the plastic and the general surgeon and to all who are interested in the restoration of function of the hand, also to the anatomist interested in certain aspects of structure and function of the human hand.

E. B. K.

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Part One

THE HAND AS AN ORGAN

1

The Hand as an Organ

The hand is an important functioning organ requiring rest and performing the greatest part of activities, including locomotion, if need be. Through the hand, as through sight and hearing, we form a conception of the outside world. It is truly the extension of our brain into the surrounding world; it is the mirror of our innermost response to the outside world.

The function of the hand can be analyzed best when divided into component parts. Although this is somewhat artificial, it permits a better insight into the activity of the hand as a unit. In order to understand the function of the human hand, it is very helpful to compare it with the function of the hands of the anthropoid apes. For different reasons in the past, and even sometimes in the present, observers suspected fundamental anatomic differences between the human and the anthropoid hand. Actual observations on the action of those hands and also on the anatomic structure show that the differences are not very great and at times indistinguishable.

The most characteristic feature of the human hand is the comparative length of the thumb and the almost constant presence of a flexor pollicis longus which permits great flexibility in the use of the thumb in conjunction with the rest of the hand. The longer thumb of man permits better opposition, mostly because of its length and the help of the flexor pollicis longus which introduces an element of stability. The thenar muscles of the gorilla and of the chimpanzee are almost exactly similar to the thenar muscles of the human hand. The gorilla has good opposition when occasion arises. The other apes have it to a lesser extent. However, their ability to seek out and grasp insects is amazing; they actually perform this action by using some opposition between the thumb and the index and the middle fingers. The nerve supply to these muscles also is very similar to the human nerve supply, as attested by many observers and the author's limited observations (Figs. 1 and 2).

The hand can be divided artificially into three functional units: (1) the thumb; (2) the index and the middle fingers; (3) the ring and the fifth fingers (Fig. 3). In the major part of human activity, the most important actions are performed between the thumb and the index and the middle fingers. The ring finger and the little finger form a supporting auxiliary. With the development of fine action, the index tends to become more and more independent of the middle finger and the ring and the little fingers. This is reflected not only in outward independence but also in separation of the muscle bellies of the index finger from the rest of the flexor profundus and sublimis in many human hands. The thumb forms a separate unit with actual separation of the flexor pollicis longus, not only low in the forearm, but also at the origin of this muscle, from the other long flexor muscles of the hand.