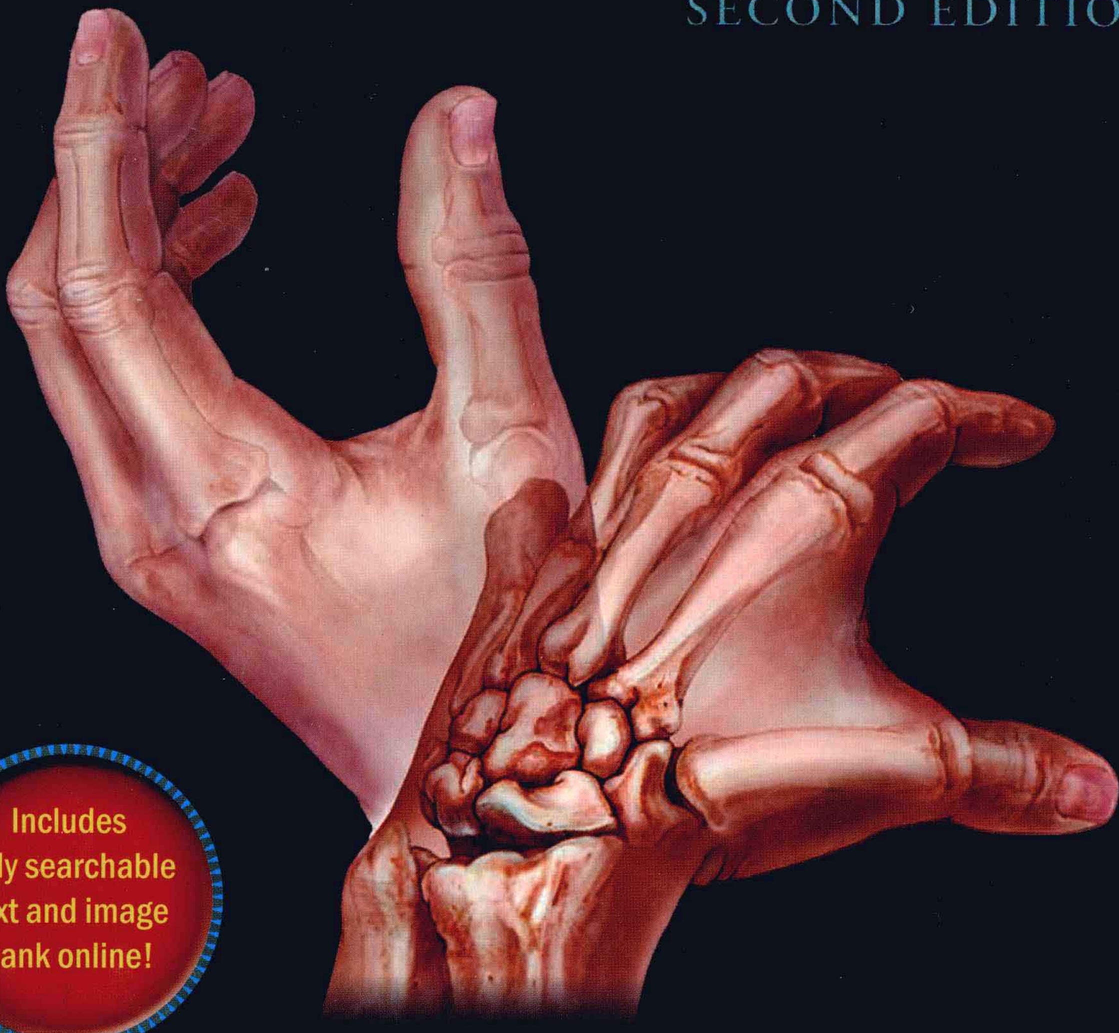
The Wrist

Diagnosis and Operative Treatment

SECOND EDITION



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Editor

William P. Cooney III, MD

Mayo Clinic Division of Hand Surgery

Wolters Kluwer Health | Lippincott Williams & Wilkins

THE WRIST
Diagnosis and Operative Treatment

SECOND EDITION

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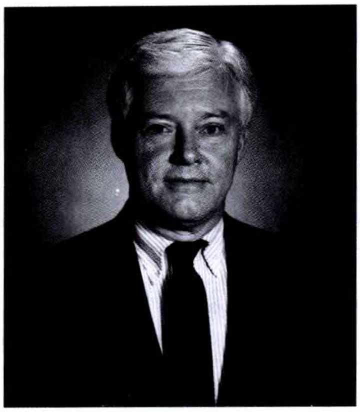

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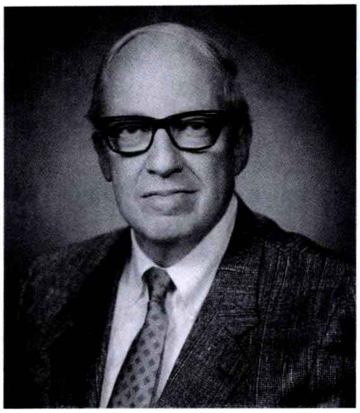

James H. Dobyns, MD

The entire current staff and past residents and fellows of the Division of Hand Surgery at Mayo Clinic dedicate this book to Ronald L. Linscheid, MD, and James H. Dobyns, MD. Professors Emeritus, Division of Hand Surgery, Department of Orthopedics Mayo Clinic. We do so noting their effective contributions to knowledge of and treatment rendered to disorders of the wrist. Drs Linscheid and Dobyns were instrumental in initiating the concept of a comprehensive book dealing with disorders of the wrist and contributed uniquely to the first edition. We thank them for their ongoing leadership.

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PREFACE

Hand surgeons, anatomists, and research scientists have had an interest in the wrist for many years, but in the past 10 years, since publication of *The Wrist: Diagnosis and Operative Treatment*, this interest has increased exponentially both locally and internationally. Significant progress has been made related to the complex anatomy and biomechanical function of the wrist, including the development of wrist and forearm mechanical simulators that can duplicate the motion and forces across the radiocarpal and midcarpal joints and the distal radioulnar joint. In association with these advances, various injuries to the wrist and reconstructive procedures of the wrist have been tested. Theories of wrist kinematic and force transmission (kinetics) have been coupled with clinical assessment of disease and injury and both static and dynamic imaging of the wrist. Both diagnostic and therapeutic arthroscopies of the wrist have further advanced the understanding of different pathologic conditions of the wrist. Surgical approaches have been modified with increased awareness of ligament anatomy and the critical support it provides for this "Rubik's Cube" of interactive carpal bones and, in particular, the intercalated segment of the proximal carpal row, which lacks any direct tendon attachments and reacts under ligament control to the forces placed on it. Attention is now directed at both volar and dorsal ligament-sparing surgical approaches to the wrist as a means to avoid injury to these important support structures. Arthroscopic surgery can now provide direct treatment of various conditions of the wrist, including excision of ganglions of the wrist, reduction of intra-articular fractures of the scaphoid and distal radius, and treatment of inflammatory diseases affecting the wrist.

Unlike the first edition of this book, which exclusively had authors who had trained at Mayo Clinic, particularly under the tutelage of Ronald Linscheid, MD, and James Dobyns, MD, this second edition includes new contributions from authorities in wrist reconstructive surgery, including several international wrist investigators. Several new chapters are also presented, including wrist outcome assessment scores, treatment subtypes for carpal instability (tenodesis/capsulodesis and intercarpal fusions), denervation procedures, acute and chronic instability of the distal radioulnar joint, and the evaluation and treatment of axial forearm instability (Essex-Lopresti lesion). Chapters from the first edition have been updated, and several have new authorship.

As for the first edition, there were three reasons for undertaking a text related to the wrist. First, Mayo Clinic has a long record of dedicated interest in the wrist, and it is appropriate to advance the science by publishing a second edition that includes new methods of evaluation, different approaches to treatment, and measures of outcome that resulted from both basic research and clinical assessment studies. We concentrated first on diagnosis and then on operative management of conditions affecting the wrist. Second, there has not been an updated text on the wrist since our first edition (1998) and the excellent publications *The Wrist* (Julio Taleisnik, 1985), *The Wrist and Its Disorders* (David Lichtman, 1988), *Master Techniques in Orthopaedic Surgery: The Wrist*, second edition (Richard H. Gelberman, 2002), and *Hand Surgery* (Richard A. Berger, Arnold-Peter Weiss, 2004). A text with an emphasis on surgical techniques is helpful to hand surgeons in practice and to residents and fellows in training. Third, having an authoritative resource limited exclusively to the wrist is timely and gives the necessary emphasis that the wrist deserves as a complex articulation of carpal bones that is an essential link between the hand and the upper extremity for the performance of many human activities.

The production of a comprehensive text required not only input from the authors and their staff but also the dedicated services of my secretary Carol Buntrock, manuscript preparation by Jane Craig and Roberta Schwartz, and manuscript reviews by the staff of the Division of Hand Surgery and the Department of Orthopedic Surgery, Mayo Clinic. Remembrance is given to Carol Kornblith, PhD, who reviewed the first edition and whose recent passing after retirement reminds us of the importance of the editorial process in providing an excellent publication. My hope is that the combined efforts of the authors, editors, and staff provide you, the wrist student, interested physicians, hand surgeons, and other devotees of the wrist, an excellent text on which to expand your knowledge and, importantly, aid patients in the diagnosis and treatment of disorders of the wrist.

William P. Cooney III, MD, Editor

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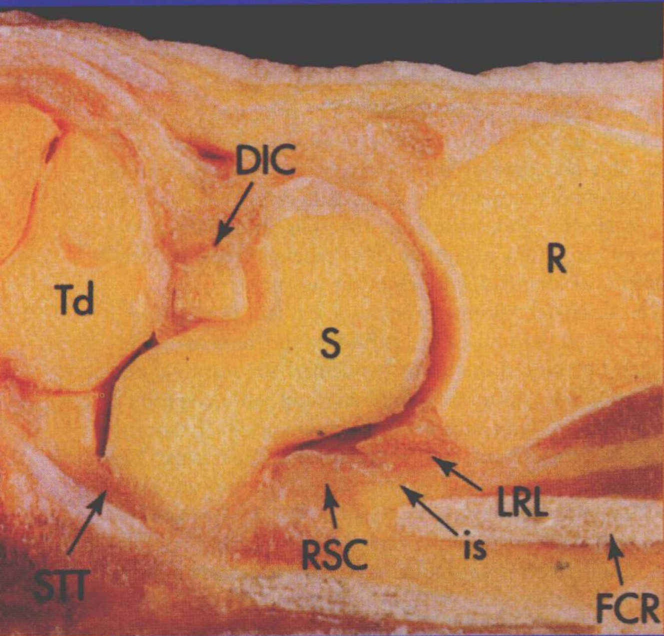

SECTION I

CARPAL COMPREHENSION

CHAPTER 1

A Brief History of Understanding the Wrist

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We may appreciate the history of the wrist joint by reading about the clinical discoveries, as detailed in articles and textbooks; the texts of Destot and Briau,[21] Fisk,[28] and Taleisnik[74] are perhaps most notable. These sources provide a unique perspective to shape our understanding of the importance of the wrist to human endeavor. The most meaningful insights have come with increasing comprehension of the anatomic and physiologic development of the wrist. The contributions that led to this increased comprehension will guide our historical journey.

The first indications we have that the ancients appreciated certain intrinsic qualities of the wrist are the semantics they applied to the structure. In Old English, the word "wrist" derives from the Teutonic *wraestan*, a root for wrest, wrestle, writhe, and twist. In French, the word for wrist is *poignet*, deriving from a root word for strength and power. In German, the words *handgelenk* or *handwurzel* pertain to hand joint. The word "carpus" apparently originated with the Greeks, derived from *karpos*, which is variously interpreted as "fruit" or "small bits of wood." In Spanish, *muneca*, the word for wrist and also the word for doll, is thought to derive from a pre-Roman word, *boneca*, which was preceded by the Celtic word *bodenecas*, which meant "site with lumps." In Arabic, the words for wrist include *musaam*, *alarassagh*, and *alssant* (we have not found the root meanings). In all instances, the wrist was named for some characteristic of its appearance or function.

Ancient medical writers seemed less concerned with the wrist than perhaps were their clientele with wrist problems, who faced the risk of prolonged disability, infection, and death. Wrist injuries of consequence were often treated by amputation, although splints and poultices might have been applied to closed injuries that did not include serious vascular or nerve damage. Medical writings more often described the level of amputation and preferred sites used for crucifixion (just proximal to the transverse carpal ligament). Full appreciation of the benefits of the versatility of the wrist has come only recently.

ANATOMY

The anatomy of the wrist, as opposed to the ankle, was largely ignored from ancient times. Galen failed to mention the carpus in his osteology. In artistic depictions from the Middle Ages, the metacarpals were shown attached directly to the forearm (Fig. 1.1). The most important development for understanding the wrist was the emergence of investigational anatomy through the work of Vesalius.[55,84] The drawings of the wrist bones by Vesalius or his artist, Stephen van Calcar, were first published in 1543 in *De Humani Corporis Fabrica Libre Septem, Book I*[84] and show several different perspectives. The carpals are numbered from the scaphoid to the pisiform as 1 through 4 and from the trapezium to the hamate as 5 through 8 (Fig. 1.2).

An interesting history of the naming of the carpal bones is related in an article by Johnson[42] and in the writings of Wood-Jones.[87] In 1653, Lyser, a prosector in anatomy in Copenhagen, named the bones of the distal row from radial to ulnar as trapezoides,

FIGURE 1.1. Drawing from a medieval text shows omission of the carpus. (From Johnson RP. The evolution of carpal nomenclature: a short review. *J Hand Surg Am*. 1990;15:834–838. Used with permission.)

trapezium, os magnum, and unciforme.[42] The proximal row, from ulnar to radial, he called pisiforme, cuneiforme, lunatum, and scaphoides. This may have been done to provide an easy formula for an articulation of a skeleton. He suggested wiring the distal row and the unciforme and pisiforme together and wiring the scaphoides and lunatum separately. This schema seems to intuitively predict later kinematic models of the wrist.

In 1726, Alexander Monro (primus) of Edinburgh transposed the names for the trapezium and trapezoid. In the same year, Albinus in Leiden introduced the terms "navicular" for scaphoid and "multangulum major and minor" for "trapezium" and "trapezoid." In Germany in 1871, Henle substituted "semilunare" for "lunatum," "pyramidal" for "cuneiforme," and "hamatum" for "unciforme." The present nomenclature was proposed by McMurrich around 1900, using Henle's version but substituting "triquetrum" for "pyramidal." He also noted that the ossification center "os centrale" forms a portion of the distal scaphoid in humans. In almost every language, people have persisted in using the terms that they find most appealing. The *Nomina Anatomica* adopted the McMurrich version[42,87] in 1955 (Figs. 1.2 and 1.3).

Perhaps a description of the carpal bones and ligaments by William Cheselden[11] in 1806 is a more objective observation on the

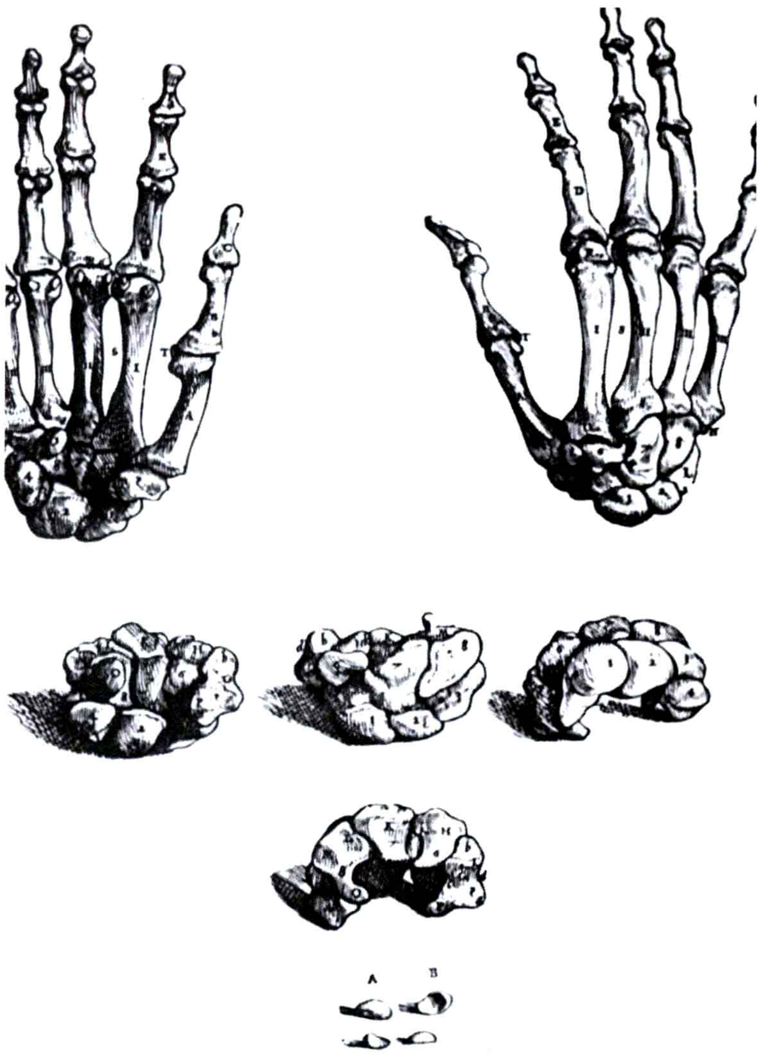

FIGURE 1.2. Wood-block illustration from Vesalius shows the numbering scheme applied to the carpus. (From Vesalius A. *Andreae Vesalii bruxellensis icones anatomicae*. Monachis: Bremensi; 1934. Courtesy of the New York Academy of Medicine Library. Used with permission.)

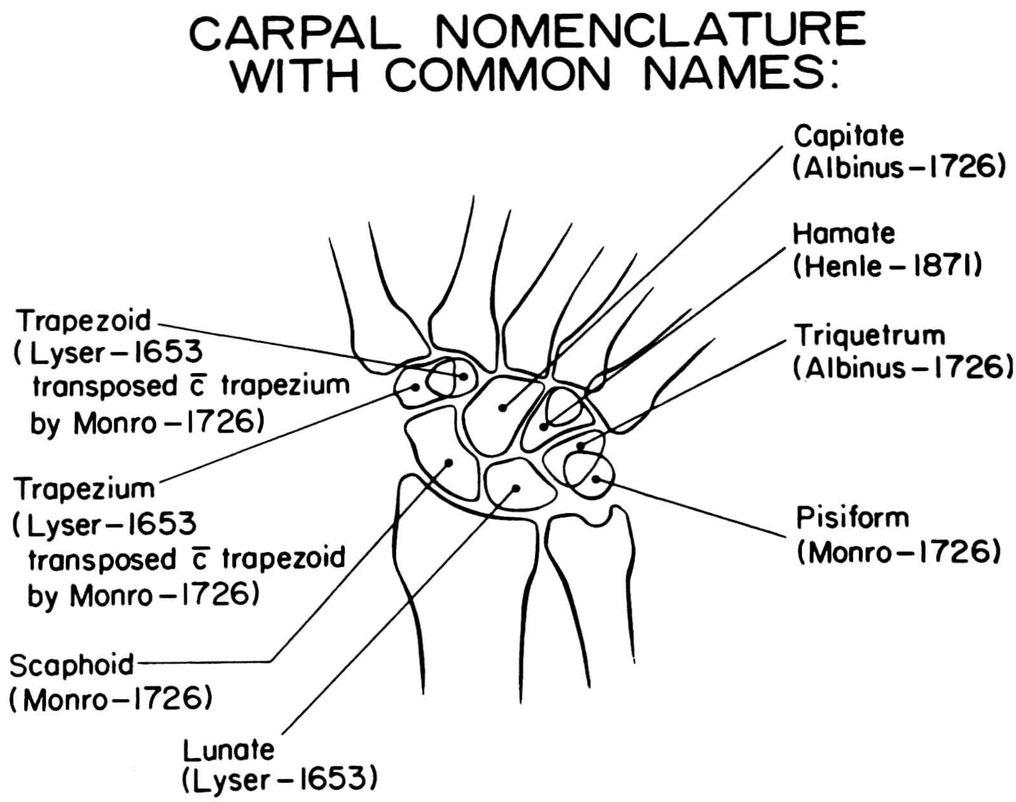

FIGURE 1.3. A comprehensive schematic of the contributions to carpal nomenclature by various authors. (From Johnson RP. The evolution of carpal nomenclature: a short review. *J Hand Surg Am.* 1990;15:834–838. Used with permission.)

difficulty of interpreting the anatomy of the wrist and on the continuing controversy over nomenclature.

> Of the bones of the hand: Carpus is composed of eight bones of very irregular forms, undoubtedly the properest that can be; yet why in these forms, rather than any other, no one has been able to show. They have all obscure motions one with another, and with those of the metacarpus; but the motion of those of the first rank, or order, with those of the second is more considerable, and are moved by the same muscles which move the carpus on the radius.
>
> The bones of the carpus and tarsus are tied together by ligaments running promiscuously upon their surfaces one to another.... There is also to the carpus a strong ligament, which runs from the fifth bone to the eighth, and the process of the fourth bone: the proper use of this is, to bind down the tendons of the muscles that bend the fingers.

From a practical clinical standpoint, a detailed anatomy of the wrist was of little more use than the above description throughout most of history. From the time of Hippocrates, most injuries of the wrist were considered radiocarpal luxations. In 1783, 30 years before Colles' description, Pouteau correctly recognized that many such injuries were the result of distal radial fractures.[20] It was not until 1820, however, when the considerable influence of Dupuytren was felt, that fractures of the distal radius were commonly acknowledged. At that point, the pendulum of opinion, influenced by Dupuytren's followers, swung so far as to almost deny the existence of dislocations at the radiocarpal joint.[12,20] Occasional reports of dislocation appeared later, and interest in the function of the wrist from a clinical as well as physiologic perspective developed, but it did so slowly and primarily in Germany at the end of the 19th century.[35–37,54,81,85]

PHYSIOLOGY

Physiology Before Roentgen

Henke was the first to systematically study carpal motion in the cadaver wrist, noting interdependent motions at radiocarpal and midcarpal joints. He considered motion in the wrist joint to occur through mutually perpendicular axes passing through the capitate, but he noted that there was no "pure" motion in the joint.[12,20] In 1873, Meyer[54] compared the proximal carpal row to a meniscus and noted that it extended during ulnar deviation of the wrist. He considered lateral motions to occur primarily at the radiocarpal joint. He noted that in both dorsoulnar and ulnopalmar movement, the ulnar deviation represented flexion at the hamatotriquetral joint and extension at the ulnotriquetral joint. Henle,[37] in 1879, described the intercarpal joint as an enarthrosis giving rotatory motion to the wrist beyond the flexion-extension movement of the radiocarpal joint. He thought adduction was confined to the radiocarpal joint and abduction to the midcarpal joint.

Interest in describing joint motions in a mechanical fashion was heightened by the publication of *Theoretische Kinematic* by Reuleaux in 1875.[34] The book described in detail the different simple and complex linkage mechanisms adaptable to machines and provided a basis for categorizing joint motions. Comparison of motions with various types of joint surfaces was investigated topologically by Fick,[27] using sections of geometric constructions.

Physiology After Roentgen

Roentgen's discovery of the x-ray in November 1895 profoundly affected study of the wrist as well as all other aspects of medicine. This is exemplified by a quote from Claude Bernard: "Each time a new and certain means of experimental analysis arises, science is always seen to progress in relation to the questions to which this method can be applied."[20]

In his 1858 book *The Human Skeleton*, Humphry had concluded, "The alternating concavo-convex facets of the two rows are so adapted to one another as to prevent all movements besides flexion and extension."[6] But by 1896, within a year of Roentgen's discovery, Bryce[6] had compared movements of his own wrist on radiographs with anatomic preparations. He found Humphry's view untenable. Bryce was incredulous after noting the incongruity between his own carpals that occurred with movement. "The carpal articulations are not locked together," as he and most anatomists had supposed from examining fixed specimens. He noted the joint space and obvious incongruity of his triquetrohamate joint and that the scaphoid flexed more than the lunate and triquetrum during radial deviation. In ulnar deviation, he noted that the scaphoid extended more than the lunate and triquetrum and the triquetrum more than the lunate. He concluded that the center of rotation of the joint must lie in the capitate, that a conjunct rotation of the proximal row occurred in the sagittal plane during lateral movement of the wrist, and that the axes of motion in the wrist resulted from a combination of motion of several joint elements. He also noted that the lunate had a screwlike motion with circumferential motion of the wrist, that the motion of the scaphoid on the lunate occurred around the stronger dorsal component of the scapholunate interosseous ligament, and that the hand pronated on the forearm in ulnar deviation and supinated in radial deviation.

In 1897, Corson[14] described the foreshortening of the scaphoid associated with radial deviation, which he stated was "due undoubtedly to a 'screw' movement on an axis diagonal to its anteroposterior and longitudinal axes." He concluded that the flexion-extension axis of rotation of the radiocarpal joint passed from the pisiform dorsodistally to the radial styloid. The axis of rotation of the midcarpal joint passed from the scaphoid tuberosity dorsoulnarly to the proximal aspect of the triquetrum. The two axes intercepted in the proximal capitate. He disparaged the suggestions of Beaunis and of Bouchard[4] that pure flexion-extension and abduction-adduction could be achieved by this arrangement. He also noted that extension aided abduction and flexion aided adduction. This small amount of axial rotation of the hand during radioulnar movement was predisposed by the ulnopalmar tilt of the distal radial articular surface, according to Jeanne and Mouchet.[41] Vaughan-Jackson[83] referred to this motion as "dart-thrower's motion."

In 1901, Rudolf Fick[26] (Fig. 1.4) constructed a three-dimensional model from which he could measure angles between recognizable points of individual carpals at the end positions of each motion on his radiographs. He described radioulnar wrist motion as occurring through the two rows of carpals, but he emphasized that the proximal row pronated during radial deviation and supinated with ulnar deviation, whereas the distal row moved in the opposite direction (Fig. 1.5A). Without this contrarotation of the two rows, the hand would rotate around the long axis of the forearm to a greater degree than is obvious to direct observation. He contradicted Henke's theory of mutually perpendicular axes for flexion-extension and radioulnar deviation through the midcapitate. Instead, he proposed oblique axes for each row that intersected in the capitate. The axis of rotation for the proximal row extended from dorsoradial over the midscaphoid to ulnopalmar at the distal aspect of the triquetrum. The axis for the distal row was roughly in the same transverse plane, but from radiopalmar to dorsoulnar (Fig. 1.5B). Fick described the relative contribution each row made to total motion in each plane. He also acknowledged the translation that occurred in the sagittal plane at the capitolunate joint, which had previously been emphasized by Virchow.[85]

FIGURE 1.4. Rudolf Fick, noted anatomist and physiologist. (From Obituary. *Deutsche Med Wochenschrift*. 1939;2:1098–1099. Used with permission.)

Destot (Fig. 1.6) suggested in 1908 that the scaphoid and cuneiform acted to connect the pillar bones of the wrist and complete the glenoid for the os magnum.[77] This view of the wrist comprising two rows of bones, with the scaphoid acting as an intermediary and supporting structure between the two rows, endorsed most of the previous concepts.[6,14,26,35,37,85] It is interesting to note the similarity of this view to the more recent "oval ring concept" of carpal stability.[49]

Destot's view was challenged by Navarro of Montevideo, Uruguay, in 1921.[56] He congratulated Destot on his fundamental studies but believed that the two lateral columns that supported the central column were fundamentally different. He categorized the central column as the flexion-extension column represented essentially by the capitolunate joint. The scaphoid, making up the radial lateral column, provided stability through the scaphotrapeziotrapezoidal joint, whereas the mobility of the ulnar column (triquetrohamate joint) allowed rotation in the frontal plane. Navarro's work also languished in obscurity until several decades ago when Scaramuzza, a student of Navarro, brought his

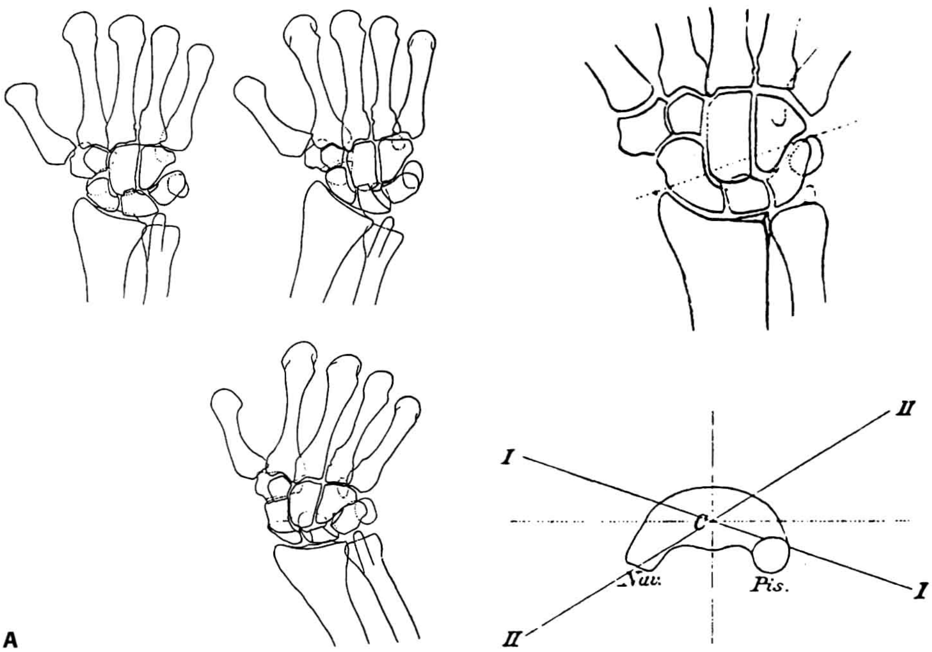

FIGURE 1.5. A. Illustration from Fick shows outline drawings taken from radiographs in radial, neutral, and ulnar deviation in the anteroposterior plane. By assuming migration of identifiable points on carpal bones, he was able to postulate the axis of motion of the two carpal rows. **B.** The axis of rotation of the proximal carpal row (I-I) induces a flexion-pronation motion in radial deviation, whereas the axis of rotation of the distal row (II-II) induces extension-supination. The motions are reversed in ulnar deviation, effectively canceling axial rotation of the hand on the forearm. (From Fick R. Ergebnisse einer Untersuchung der Handbewegungen mit X-strahlen. *Anat Gessel Verh.* 1901;15:175–184.)

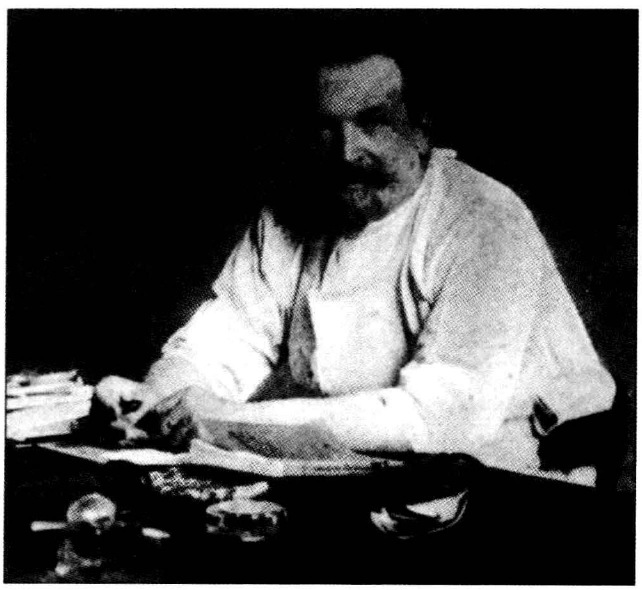

FIGURE 1.6. Etienne Destot, pioneer in combining studies of wrist anatomy, clinical conditions, and radiographic interpretations in a comprehensive fashion at the dawn of the roentgenographic era. Note radiation deformities of his fingers. (From Gallois E, Aigrot G, Japiot P. Etienne Destot [obituary]. *Lyon Chir.* 1919;16:8–134.)

publications to the attention of Taleisnik, who then modified the concept slightly and popularized the concept of the three-column wrist.[56–59,66,75]

The triquetrohamate joint has been considered, by most of the authors mentioned here, to have a fundamental role in lateral motion of the wrist. The short segment of opposed helical surfaces of the two bones has been implicated particularly in control of adduction. Following the same line of reasoning, Weber[86] proposed that the "high or low position" of the triquetrum on the hamate influenced the rotation of the proximal row during radial and ulnar deviation.

DESTOT: PROTAGONIST OF THE POST-ROENTGEN PERIOD

No one better exemplifies the protagonist of the exciting decade that bridged the 19th and 20th centuries than Etienne Destot of Lyon, France (Fig. 1.6). He was born in 1864 in Dijon, a small town 100 km north of Lyon. After medical school, he began his residency in Lyon in 1888. As a resident, he showed great interest in anatomy and surgery. Six of his residency stages were devoted to surgery, one of them being with the famous orthopaedic surgeon, Louis Leopold Ollier. Destot was honest, inventive, and enthusiastic. His medical thesis was held in 1892, with Ollier in attendance. The title of his thesis, "Death Rates in Lyon Surgery Services," made the young Destot rather unpopular among the head surgeons, as may be imagined.