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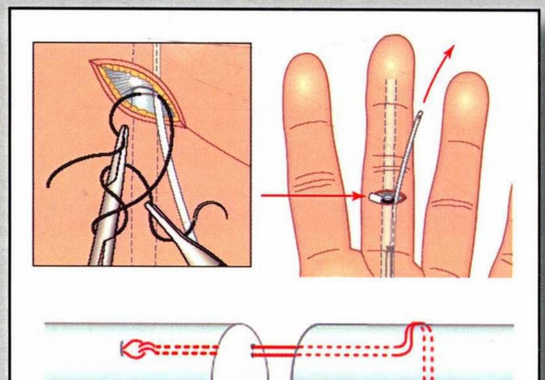
TENDON SURGERY OF THE HAND



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TENDON SURGERY OF THE HAND

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DEDICATION

I dedicate this book to my parents, Cheng Hua Tang and Xiou Feng Zhao; my wife, Xiao Tian; and my daughter, Yu-Qing. Their support, understanding, and sacrifice are the most fundamental to my past work and completion of this book.
I also dedicate this book to my colleagues all past and present members of the Research Center and the Department. In particular, it is dedicated to an inspiring professor and tendon enthusiast: Seiichi Ishii, who mentored me in my first work on tendons.

Jin Bo Tang, MD

This book is dedicated to my wife, Bari, for her continuous emotional support and understanding; to my clinical colleagues at Mayo Clinic, for their daily inspiration and for their generosity in accommodating the many demands that the creation of this book has required; and to my many mentors in tendon surgery over the years, especially James M. Hunter, MD, whose high standards of tendon surgical skill and creativity I can only hope to emulate.

Peter C. Amadio, MD

I would like to thank two illustrious colleagues, Harold Kleinert and Claude Verdan, for influencing my way of thinking in tendon surgery and for lighting the path for me to perform vascularized tendon grafts. They never wavered in their support for my work, and they encouraged me to continue investigations.

Jean Claude Guimberteau, MD

I wish to thank my family—James Sr., Lily, Anthony, Barbara, and Cecilia Chang; Harriet Roeder; and Julia, Kathleen, and Cecilia Roeder Chang—for their constant love and support. I also wish to honor all the research fellows, residents, and hand fellows at Stanford who have worked so tirelessly; and my surgical mentors, Vincent Hentz, Neil Jones, and Roy Meals, who have taught me so much about the hand.

James Chang, MD

PREFACE

This book, *Tendon Surgery of the Hand*, is intended to address the lack of a comprehensive and up-to-date textbook on the basic science and clinical practice of tendon surgery in the hand.

Tendon surgery is one of the most important topics in hand surgery; its importance to hand function and its allure to hand surgeons are well-reflected in the vast number of investigations and publications devoted to this topic. Surprisingly, however, no comprehensive book on tendon surgery of the hand (or of other parts of the body) has been published in the last 25 years, despite revolutionary changes in the treatment of tendon injuries and disorders. The only landmark book on tendons is Hunter's *Tendon Surgery in the Hand*, from 1987. Therefore, we organized a group of international experts in tendon surgery to produce a new volume. The idea of compiling such a textbook was initiated during a conference in Manchester, UK, in 2006 and was subsequently reshaped, with updated media technology, by Elsevier with publication of both print and online versions.

Since the mid-1980s, the clinical practice of tendon surgery has evolved considerably, and a great number of innovative techniques have emerged. They include a myriad of novel repair techniques, use of new suture materials, novel tendon sheath and pulley treatments, vascularized tendon grafts, and the development of various postoperative rehabilitation methods. With regard to the basic science, a wealth of new knowledge has been accumulated. Our knowledge of tendon biology and biomechanics has increased greatly, and a number of new research fields—such as gene therapy, tissue engineering, stem cell delivery, and gene silencing—have emerged. Advancements in updated clinical techniques and cutting-edge technologies in the basic science of tendon surgery are comprehensively summarized in this book.

This book contains a total of 46 chapters (41 print and online chapters and 5 web-only chapters), organized in five sections: basic science, primary flexor tendon surgery, secondary flexor tendon surgery, extensor tendon repair and reconstruction, rehabilitation of tendon surgery, and the future of tendon surgery. We have aimed to include a worldwide selection of investigators, surgeons, and therapists to author the text. These chapters are contributed by respected surgeons/investigators from renowned centers and innovative surgeons who offer unique and insightful techniques.

It is our essential goal to offer comprehensive coverage of international perspectives and techniques currently used in tendon surgery of the hand. In particular, the section on primary flexor tendon repair and rehabilitation is a genuinely international collaboration, highlighting methods and protocols of different units; it is sure to provide readers with an abundance of information, allowing them to judiciously plan their own treatments based on the surgical and post-surgical care principles described in the chapters. Extensor tendon injuries are another topic with various treatment options. Considering the variety of techniques and rehabilitation protocols currently used, we have planned the related surgical and rehabilitation chapters to reflect diverse approaches to the injuries. Further, multiple therapy protocols were contributed from the leading hand units across the world; these protocols are published online to provide the readers with rich and authoritative references for deciding on treatment course for extensor tendon injuries.

We are greatly indebted to the contributors from 15 countries spanning four continents; their high quality contributions are the cornerstones of this book. Notably, we should give our earnest gratitude to Dr. David Elliot and Ms. Judy Colditz, our guest editors. Not only are both eminent educators with vast experience on tendon problems—as a surgeon and a therapist, respectively—but they are also keen editors who have tirelessly devoted their effort to this book. Dr. Elliot contributed his own crystallized experience in seven chapters of this book and also edited a portion of the primary and secondary repair chapters. Ms. Colditz coordinated and helped edit the chapters relating to rehabilitation. Furthermore, we greatly appreciate the surgeons and therapists who contributed therapy protocols in the online appendix and video clips to enhance the contents of this book.

Finally, we feel obliged to express our appreciation to the Elsevier staff and editors, especially Dan Pepper, acquisition editor; Don Scholz, senior content strategist; Mary Beth Murphy, developmental editor; Heather

Krehling, content development manager; and Brandilyn Tidwell, project manager. Without their advice on content and careful copyediting, it would not have been possible to accomplish this project. We also give our great appreciation to the Elsevier art team for providing superb color illustrations for this book, helping us present our readers with a complex surgical topic in an easily readable way.

We hope that this textbook helps practitioners, fellows, residents, and medical students understand or master key concepts and techniques of tendon surgery of the hand and aids in treatment planning of the often worrisome problems relating to the tendon of the hand.

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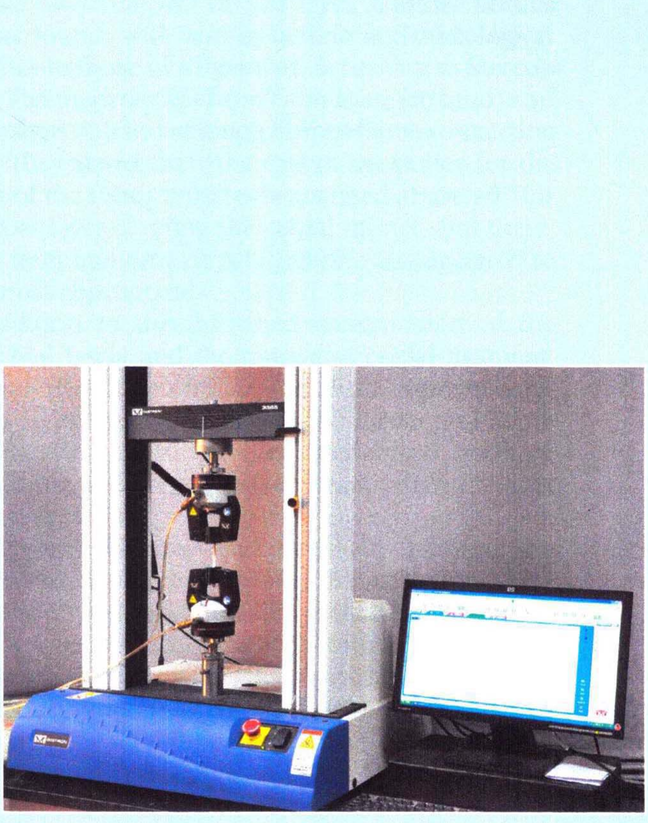
SECTION 1

BASIC SCIENCE



CHAPTER

1 ANATOMY OF THE TENDON SYSTEMS IN THE HAND

Robert J. van Kampen, MD, and Peter C. Amadio, MD

OUTLINE

This chapter describes the anatomy of the flexor and extensor apparatus in the hand and wrist, supplemented with relevant clinical and biomechanical features. It emphasizes the key importance of the retinacular structures of the wrist and fingers and reviews both normal anatomy and common variations of the flexor and extensor tendons in the hand. Special attention is given to the vincula tendinea and pulleys supporting the flexor tendons in the digital flexor sheaths—in particular, the structure and biomechanics of the pulley system. The key role of the A2 and A4 pulleys is emphasized. Finally, a closer look is taken at the tendons and bands contributing to the extensor mechanism, and their action on the metacarpophalangeal and interphalangeal joints is discussed.

The hand, with the carpus, is the most complex collection of interconnected joints in the human body, and a large assembly of tendons carries out its extensive range of motion. Distinctive groups of muscles execute the actions of these tendons on the hand. Together with numerous aiding structures, the tendons form an ingenious biomechanical system that gave humans the ability to perform complicated tasks and develop dexterous professions that require sophisticated hand and finger movement, like hand surgery. Treatment of hand disorders is similarly delicate and complex; therefore, a thorough understanding is essential to provide adequate treatment.

FLEXOR RETINACULUM

On the volar aspect of the wrist, the carpal bones form a deep excavation over which the *flexor retinaculum* arches, creating the carpal tunnel. The tendons of the flexor digitorum superficialis (FDS) and profundus (FDP) and the flexor pollicis longus (FPL) pass through this tunnel together with the median nerve.

This retinaculum inserts on the ulnar side into the pisiform bone and the hook of the hamate and is reinforced by the pisiform-hamate ligament. On the radial side, the retinaculum firmly inserts into the volar ridge of the trapezium (trapezial tuberosity) and the tubercle of the scaphoid. Occasionally an insertion into the styloid process of the radius can be seen.[1,2]

Controversial terminology surrounds this strong, fibrous band that crosses the volar side of the carpus. According to the *Terminologia Anatomica,* the term *flexor retinaculum carpi* should be used. However, in textbooks, the terms *flexor retinaculum, transverse carpal ligament* and *anterior/volar annular ligament* are used for the same structure.[3]

In hand surgery, it is often preferred to distinguish between the different parts of the flexor retinaculum. Stecco et al[3] investigated its histological and anatomical features. Continuous with the antebrachial fascia, a fibrous reinforcement was identified at the volar side of the wrist. After removal of this layer, another fibrous layer was found, with strong lamina and histological similarities to those of a ligament. According to Stecco's group,[3] "ligament derives from Latin *ligare* (to bind) and means a sheet or band of tough fibrous tissue connecting bones." They stated that "the role of the pulley for the tendons of the flexor muscles is assumed above all" for this deeper layer covering the carpal tunnel, and therefore the term *transverse carpal ligament* was suggested to be the most appropriate.

In addition to the thickened continuation of the antebrachial fascia and the transverse carpal ligament, Cobb et al[4] described a third, more distal segment composed of an aponeurosis between the thenar and hypothenar muscles. Based on their anatomical findings, they advocate a more extensive release when dividing the carpal ligament.

Tanabe and Okutsu[5] endoscopically released the flexor retinaculum in management of carpal tunnel syndrome and found that the mean distance between the ends of the retinaculum increased from 1.3 mm to 6.6 mm if the distal fibers were also divided. They therefore concluded that sectioning of the distal fibers is essential for endoscopic carpal tunnel release.

EXTENSOR RETINACULUM

On the dorsal side of the wrist, a thickened part of the deep antebrachial fascia is found, holding the tendons of the extensor muscles in place. It works in continuity with the volar carpal ligament and for the previous stated reasons the term *dorsal carpal ligament* or *posterior annular ligament* could also be suggested. However, the term *extensor retinaculum* is most commonly used.

As studied by Taleisnik et al,[6] the deep antebrachial fascia begins to thicken proximal to the radiocarpal joint and becomes the *dorsal annular ligament*, a component of the extensor retinaculum of the wrist. Distally, this *supratendinous layer* is continuous with the pretendinous fascia of the hand. On the ulnar side, it inserts in three distinct places: proximal around the flexor carpi ulnaris tendon, the middle part into the triquetrum and pisiform bone, and distally onto the fascia of the abductor digiti quinti and base of the fifth metacarpal.

The retinaculum attaches to ridges on the radius, forming septa that divide the space below the extensor retinaculum in six compartments through which the extensor tendons pass. The six compartments are further described in the section about extensor tendons.

Within the supratendinous layer, at the floor of the fourth and fifth compartment, lies the *infratendinous layer*, from which circular fibers form a tube around the tendons within the compartments. In the sixth compartment, a duplication of the infratendinous layer forms a tube around the extensor carpi ulnaris (ECU) tendon from the ulnar styloid to the triquetrum. This subsheath stabilizes the tendon along the groove in the distal ulna and contributes to the stability of the distal radioulnar joint. Proximally, longitudinal fibers form the *linea jugata* that reinforces the tendon to prevent subluxation during full supination. The ECU subsheath is frequently injured, typically in young athletes who play racket or stick sports, which can result in recurrent subluxation of the ECU tendon.[7]

FLEXOR TENDONS IN THE HAND

The tendons in the wrist have a relatively constant arrangement with the median nerve. This arrangement varies mainly when muscle or tendon anomalies are present. It is important to keep these variations in mind, because it can be confusing even for the experienced surgeon. Usually, the median nerve can be found directly under the tendon of the palmaris longus. Sometimes, the nerve lies more superficial, next to the palmaris longus tendon. The median nerve is also frequently observed to split in the forearm.[8]

The palmaris longus tendon lies completely enclosed in the deep fascia of the forearm between the superficial veins and cutaneous nerves. The presence of this tendon is highly variable, as its absence has been reported from 0.6% to 63.9% (either bilateral or unilateral) among different populations all over the world.[9] In humans, this tendon is seen as rudimentary, and for that reason, and its easy accessibility, the palmaris longus is often used as a tendon graft.

To the radial side of the median nerve, the FPL tendon can be found; to the ulnar side, the superficial flexor tendons. When coursing through the carpal tunnel the superficial flexor tendons are arranged in pairs, the tendons to the middle and ring finger form the superficial pair, and the little and index finger tendons form the deep pair. Dorsal to the superficial tendons lie the flexor profundus tendons.[2,8]

In the case that the palmaris longus tendon is absent, the tendon of the flexor superficialis indicis can sometimes be found between the superficial flexor tendon to the middle finger and the median nerve. In other variations, the palmaris longus tendon can separate into two or three tendons, the muscle can be doubled, the muscle can be reversed or inverted, and partial or complete insertion in the antebrachial fascia can be seen. Additionally, insertion into the pisiform bone, scaphoid, flexor carpi ulnaris tendon, and muscles of the thenar has been observed.[8]

Accessory slips for the FDS and FDP are frequently observed, especially to the index finger. Slips arise from the ulnar tuberosity to the superficialis tendon of the index and middle finger, and from the annular ligament to the superficialis tendon of the little finger. The superficialis tendon to the little and index finger can be absent and the index finger's deep flexor tendon can divide into two tendons or have a shared origin with the FPL.[8]

The flexor carpi radialis (FCR) tendon courses through its own synovial sheath that forms a narrow osteofibrous tunnel when passing the trapezium. The radial side of the tunnel is formed by the body of the trapezium and the volar side by the trapezial tuberosity. On the ulnar side, the tunnel is separated from the carpal tunnel by a thick septum. Distally, the FPL tendon pivots around this septum. At the floor of the tunnel, the tendon sheath lies in contact with the volar capsule of the scaphotrapeziotrapezoid (STT) joint. The narrow tunnel induces a higher risk of primary stenosing tenosynovitis; however, because of the close relationship with surrounding structures, tenosynovitis can also occur secondary to traumatic or degenerative changes. Tenosynovitis of the FCR tendon is not an uncommon finding in arthritis of the STT joint, which can cause additional pain to the baseline osteoarthritic pain.[10,11]

The FCR tendon is also suggested to play a role in stabilizing the scapholunate joint through its close relationship between the FCR tendon sheath and the ligaments attached to the tuberosity of the scaphoid. The tendon was thought to use the distal pole of the scaphoid as a pulley to increase its mechanical advantage and prevent the scaphoid from rotating into flexion. Unlike in previous hypotheses, Salvà-Coll et al[12] found that