Developing an Anatomically Sound Hand Position for Clarinet Playing

Sheri Rolf, MD

Introduction

Every clarinetist strives to achieve a fluid, effortless technique. One critical element in working toward this goal is the establishment of a good hand position. Clarinet pedagogical literature describes hand position in a variety of ways, but conspicuously absent in all of these discussions is any attempt to relate playing position to the actual anatomical structure of the hand. [1] [2] [3] Students are often advised that the hands should be positioned as if "holding a tennis ball" while playing the instrument. [4] As it turns out, this results in an ideal functional position, gently curving the fingers and preserving the three natural arches of the hand. Thus, the most efficient hand posture for playing the clarinet is based upon sound anatomical and biomechanical principles that should also minimize the stresses placed upon the intrinsic structures of the hand. A novel approach to assist the clarinetist in developing this optimal hand position is described herein.

Discussion

A fluent technique is a key element of excellent clarinet playing. Impeccable timing and precise coordination of the fingers are essential to developing such a technique—along with countless hours of practice. The amount of time invested in practice and study by a twenty-two year old violinist performing a concert debut has been estimated to exceed 15,000 hours.[5] It would seem reasonable to assume that a clarinetist must have an equivalent time investment in achieving a similarly high level of performance. Untold further hours of practice are required to maintain proficiency throughout one's career. During these long hours, the hands are called upon to perform numerous repetitions of scales, exercises, and difficult passages. The wisdom of maintaining an efficient and relaxed hand position seems obvious.

Pedagogues have described the ideal hand position for playing the clarinet in a variety of ways.[6] [7] [8] All of these instructors are in agreement that the fingers should be curved or arched to position them optimally over the keys and tone holes of the instrument. They acknowledge that the hands should be free of tension, and further agree that the fingers should move from the knuckles. Sometimes this position is described, "as if holding a tennis ball" in the hand.[9] Anatomically, this is very sound advice.

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[1] Carmine Campione, *Campione on Clarinet* (Fairfield, OH: John Ten-Ten Publishing, 2003), 29.
[2] Larry Guy, *Hand & Finger Development for Clarinetists* (Stony Point, NY: Rivernote Press, 2007), 9-17.
[3] Keith Stein, *The Art of Clarinet Playing* (Van Nuys, CA: Summy-Birchard Inc., n.d.), 28-31.
[4] Stein, *The Art of Clarinet Playing, 29.*
[5] Peter F. Ostwald, Barry C. Baron, Nancy M. Byl, and Frank R. Wilson, "Performing Arts Medicine," *Western Journal of Medicine* 160 (1994): 48.
[6] Campione, *Campione on Clarinet,* 29.
[7] Guy, *Hand and Finger Development,* 9-17.
[8] Stein, *The Art of Clarinet Playing,* 29.
[9] Stein, *The Art of Clarinet Playing.*

The hand is an incredibly complex mechanism consisting of twenty nine bones which are acted upon by twenty-four muscle groups to allow a myriad of possible movements.[10] Even though volumes have been written on the subject, most musicians possess very little knowledge of the anatomy of the hand and how it functions. This is unfortunate. It has been demonstrated that music students who received a weekly two hour course on anatomy, physiology, and instrument-specific exercises exhibited a significant reduction in musculoskeletal symptoms[11] Some music schools are now offering such courses, and centers for the study of performance biology are starting to emerge. As more clarinetists become aware of the anatomy of the hand, it is hoped that ambiguous terms, such as "bent wrist" will no longer appear in pedagogical literature.[12]

So, how is one who is not fortunate enough to have access to a course in performance biology to garner an understanding of a system as complex as the human hand? One method is to resort to a childhood pastime and use a coloring book! A number of human anatomy coloring books are currently available. The Appendix contains plates from *Netter's Anatomy Coloring Book* by John T. Hanson.[13] A similar coloring book by Poritsky is dedicated entirely to the upper extremity.[14] These books are accurate and contain ample detail. The anatomical terminology is still there, but it is much more difficult to be intimidated by it while wielding a crayon in one's hand. It may be helpful to refer to the plates in the Appendix while reviewing the descriptions that follow.

The body's most complex joint, the wrist, is formed by eight carpal bones which are arranged in two rows. They are arranged in the form of an arch and are tightly bound together. The carpal arch, as this is known, forms the skeletal portion of the carpal tunnel. Although numerous structures pass through the carpal tunnel, the best known of these is the median nerve. Compression of the median nerve in this location is the cause of carpal tunnel syndrome. The carpal arch, its contents, attachment to the metacarpals, and the tough fibrous covering comprise the framework of the proximal transverse arch.[15] The proximal transverse arch is one of the three arches of the hand that will be preserved by developing a good hand position for playing the clarinet. In Figure 1, the location of the proximal transverse arch is shown by the blue line. This is the only arch of the hand that is structurally fixed.

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[10] C.L. Taylor & R.J. Schwartz, "The Anatomy and Mechanics of the Human Hand," Accessed Nov. 25, 2010 from http://www.oandplibrary.org/al/1955_02_022.asp

[11] C. Spahn and H. Hildebrandt, "Effectiveness of a Prophylactic Course to Prevent Playing-related Health Problems of Music Students," *Medical Problems of Performing Artists,* 16 (2001), 24-31.

[12] Earl Thomas, "Anatomical Essentials in Clarinet Hand Position," *The Clarinet* 20 (1993): 18-21.

[13] John T. Hanson, *Netter's Anatomy Coloring Book* (Philadelphia: Saunders Elsevier, 2010) .

[14] Ray Poritsky, *Hand and Upper Extremity Anatomy to Color and Study* (Philadelphia: Hanley & Belfus, Inc.: 2000).

[15] Gwenda Sharp and Dave Thompson, "Biomechanics of the Hand," Accessed November 25, 2010, from *Control of Human Movement I & II,* http://moon.ouhsc.edu/dthompso/namics/hand.htm

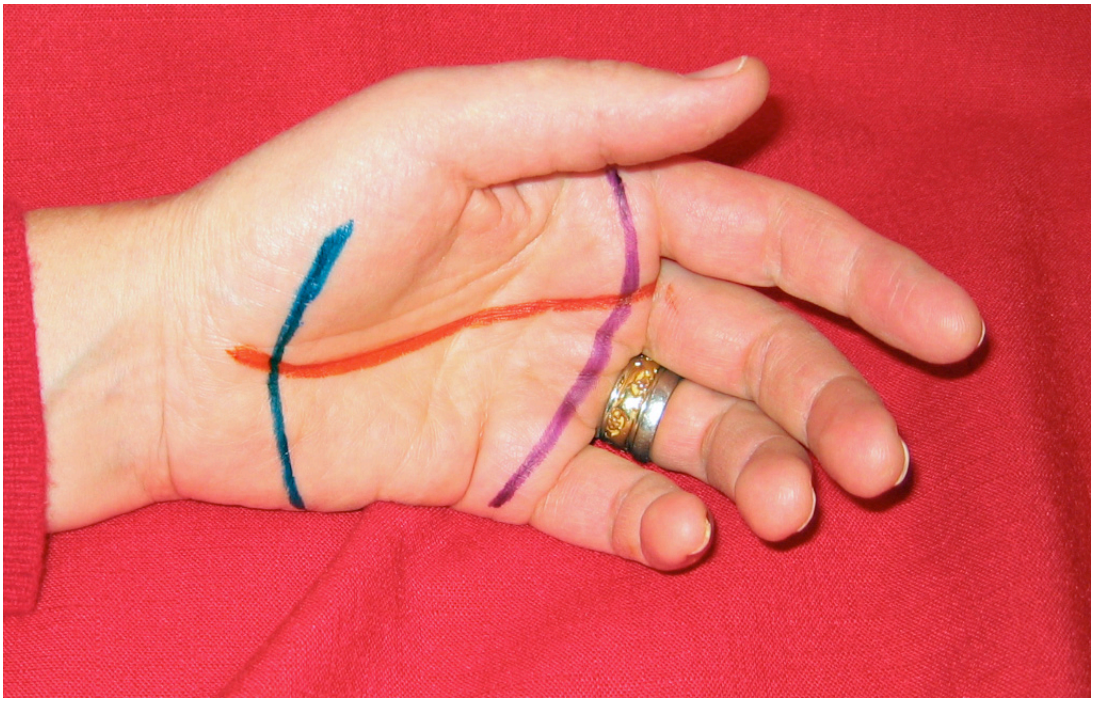


Figure 1. The three arches of the hand provide a balance between stability and flexibility.

The digital movement involved in playing the clarinet is described as coming from the knuckles. These joints are more properly referred to as the metacarpophalangeal (MP) joints. They are formed by the articulations of the heads of the metacarpal bones with the proximal phalanges of the digits. The MP joints are far from simple hinges. They allow the fingers to be spread apart (abduction), drawn together (adduction), or to be moved in an arc (circumduction). The MP joints are flexed by the lumbrical and dorsal interossei muscles, all of which are intrinsic muscles located entirely within the hand. The MP joints are also acted upon by the extrinsic muscles of the hand which are located in the forearm. Due to the distance from the forearm muscles to the phlanges, these extrinsic muscles have long tendons that must glide smoothly through a series of tunnels and pulleys in order to move the fingers. These gliding motions are greatly facilitated by a maintaining a natural relaxed hand posture.

The distal transverse arch of the hand is represented by the purple line in Figure 1. This is formed by the arrangement of the MP joints. The longitudinal arch is shown in red in Figure 1. Unlike the proximal transverse arch, these two arches are flexible allowing for a myriad of possible hand motions. Both of these arches are maintained by the intrinsic muscles of the hand. For playing the clarinet, it is important that the arches of the hand remain stable but not rigid, and mobile, but not lax. Arches are structures that have been used in engineering and architecture for centuries due to their strength and ability to minimize tensile stresses. The three arches of the hand are essential to providing a stable platform from which the MP joints can move with fluidity and precision while raising and lowering the fingers onto the keys of the clarinet. These are the arches which result naturally when a tennis ball is held in the hand. In other words, the tennis ball places the hand in a natural, relaxed position with the biomechanical stability necessary to play the clarinet.

Unfortunately, a tennis ball cannot be held in the hand while the clarinet is being played. The size of the ball is too large to be retained in most average-sized hands while a working musician-instrument interface is maintained. Moreover, even if the size of the tennis ball did not interfere with the mechanics of opening and closing the keys of the instrument, the attempt to hold a spherical object in the palm of the hand while playing the clarinet would quickly degenerate into a juggling act. The slightly smaller size of a racquetball, 5.7 cm (2.25 inches) in diameter, as opposed to that of a tennis ball, 6.7 cm (2.7 inches) allows the racquetball to fit in the palm where it maintains the arches of the hand in their correct posture (Figure 2). By attaching a strap to the racquetball, it can be kept in the hand of the musician while the clarinet is actually being played (Figure 3).

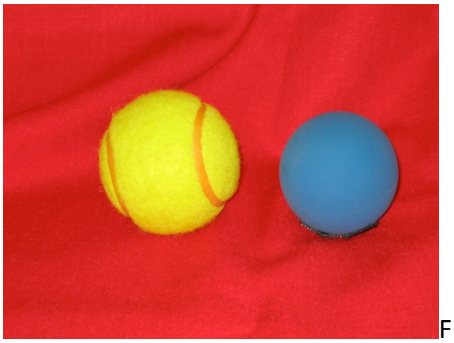


Figure 2. Note the size difference between the tennis ball (6.7 cm diameter) on the left and the racquetball (5.7 cm) on the right.

Figure 3. Note that the use of the racquetball tool results in a stable but flexible hand position that favors movement from the MP joint while playing the clarinet. The size of the balls makes it possible to play the instrument without significant interference with the operation of the keywork. The straps keep the balls from falling out of the hands, and, because they are made of Velcro, it is very quick and easy to adjust, remove, or replace the balls as necessary.

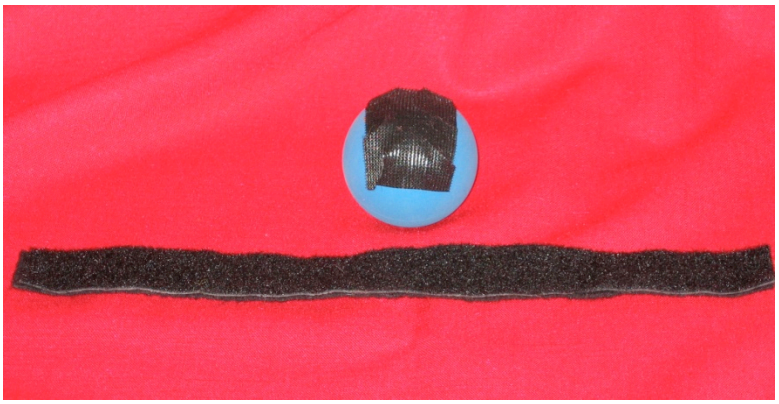


Figure 4. Making the racquetball hand position device

Making the racquetball hand positioning device is straightforward. All that is required is a racquetball and self-adhesive hook and loop (Velcro) material (Figure 4). A patch of the hook material is placed on the ball. The strap is cut from a suitable length of the loop material. The strap is placed around the hand as shown in Figure 5 to keep the racquetball in the palm of the hand. Note how the hand drapes into a natural, relaxed posture around the ball. The size of the racquetball causes little if any interference with the key mechanism while the hook and loop strap facilitates its application and removal. Most importantly, no physical modification of the clarinet is necessary. For players with even smaller hands, a handball may be substituted for the racquetball. The end result is a simple, inexpensive device to support the posture of the hand while strengthening and muscle memory occur. Further study will be necessary to determine whether the use of this tool may play a role in the prevention of playing related injuries of the hand.

Figure 5. The hand drapes around the racquetball in a natural, relaxed posture.

Conclusion

The hand is an immensely complex structure. When applied to the clarinet, it is capable of fluid movement to create music. But in this process, it is exposed to countless hours of repetitive practice. A natural, relaxed hand posture based upon the three anatomical arches places the hand in an ideal position to facilitate finger movement from the MP joint while allowing for proper alignment of the gliding movement of the numerous tendons which must glide smoothly to move the fingers. This posture can be achieved by using a simple device fashioned from a racquetball that may be strapped into the hand of the clarinetist. A basic understanding of human anatomy as it applies to playing the instrument should be a component of every clarinetist's training. Hopefully the emerging study of performance biology will flourish and allow widespread access to this heretofore comparatively neglected aspect of music education and performance.

Bibliography

American Society for Surgery of the Hand. *Hand Anatomy.* 2009. http://www.assh.org/Public/HandAnatomy/Pages/default.aspx (accessed November 30, 2010).

The anatomy drawings on this page are intended to assist patients in explaining their symptoms to their physicians. They are straightforward and clearly labeled. There are links to other pages within the site that contain more detailed illustrations as well as information on many of the conditions that may affect the hand.

Barron, O. Alton, and Richard G. Eaton. "The Upper Limb of the Performing Artist." In *Performing Arts Medicine*, by Robert Thayer Sataloff, Alice G. Brandfonbrenner and Richard J. Lederman, 231-260. San Diego: Singular Publishing Group, Inc., 1998.

With its decidedly clinical emphasis, this chapter might prove to be a bit daunting for the reader with little background in anatomy. A variety of injuries to and conditions of the upper limb are described. The chapter contains a table that summarizes the function and innervation of the muscles of the upper extremity.

Bejjani, Fadi Joseph; Kaye, Glenn M. ; Benham, Melody. "Musculoskeletal and Neuromuscular Conditions of Instrumental Musicians." *Archives of Physical Medicine and Rehabilitation* 77 (Apr. 1996): 406-413.

In this review article, the authors have included a great deal of information in a relatively condensed form. Although the bulk of the article is concerned with overuse syndrome, a number of neuropathies that may occur in musicians are also described as is focal dystonia. Ergonomic s and modifications of technique and equipment in order to relieve tension are advised to minimize injuries to performers. There is an extensive bibliography.

Brandfonbrenner, A.G. "Musculoskeletal Problems of Instrumental Musicians." *Hand Clinics* 19 (2003): 231-239.

This article provides an overview of some of the musculoskeletal problems that may be experienced by musicians. Risk factors are explored as are some instrument-specific mechanisms of injury. Management options are discussed, including relative rest, splinting, and exercise. The importance of prevention is stressed.

Campione, Carmine. *Campione on Clarinet.* Fairfield, OH: John Ten-Ten Publishing, 2001.

Written in an informal, conversational style, Campione's monograph on playing the clarinet covers a wide variety of topics which include hand position and fingerings. The text is based entirely upon his extensive experience in both performing and teaching. The book contains no bibliography or references.

Chesky, Kris S.; Kondraske, George; Rubin, Bernard. "Effect of Elastic Neck Strap on Right Thumb Force and Force Angle During Clarinet Performance." ***Journal of Environmental and Occupational Medicine*** **42, no. 8(Aug. 2000): 775-776.**

The authors present a study of the performance angles and forces upon the right thumbs of nine clarinetists playing both with and without neck straps. They conclude that the use of the neck strap resulted in an overall decrease of forces on the thumb and suggest that its use might decrease the risk for cumulative trauma disorder in clarinetists.

Dawson, William J. "The Clarinet." in ***Motions of Wind Instrument Performance*****. Performning Arts Mediicine Association. 2006: 15-19. http://www.artsmed.org/WilliamDawson-Motions.pdf (accessed November 25, 2010).**

This article begins with an overview of the various musculoskeletal motions and stresses involved in supporting and playing the clarinet that should prove quite useful to the clinician with limited knowledge of the instrument. Movement patterns are described as are the ranges of motion observed in the right upper extremities of a group of clarinetists.

Farmer, Gerald J. "Use of the Clarinet Neckstrap." ***Woodwind World-Brass & Percussion*** **(June, 1979): 8-9.**

A brief anecdotal article describing the author's experience with using a neckstrap to help alleviate pain in his right hand while playing clarinet. He offers use of a neckstrap as an option for others with similar problems as well as for beginning clarinet students.

Flake, L. Michael. "Fundamentals to Emphasize on Clarinet and Saxophone: An Interview with Richard Nunemaker." ***The Instrumentalist*** **54, no. 9 (Apr. 2000): 36-44.**

In this interview, Nunemaker states that the biggest problem for young students of the clarinet is hand position. He recommends looking for a "C" shape between the first finger and thumb of both hands in his description of how he teaches hand position. Other topics addressed include embouchure, tone production, and more.

Fry, H. J. H. "Prevalence of Overuse (Injury) Syndrome in Australian Music Schools." ***British Journal of Industrial Medicine*** **44 (1987): 35-40.**

Overuse injury is defined, and risk factors for developing this problem are outlined. Included is epidemiological data on the prevalence, severity and duration of symptoms in students of seven of Australia's music schools is presented. Recommendations for preventing such injuries are outlined.

Fry, H.J.H. "The Treatment of Overuse Syndrome in Musicians. Results in 175 Patients." ***Journal of the Royal Society of Medicine*** **81 (Oct. 1988): 572-575.**

Outlined by specific instrument, results of treatment for overuse injuries in musicians from a number of professional orchestras and music schools are presented. Fry emphasizes that attention to playing technique and body awareness may be the only treatment required for mild problems and that injuries tend to worsen unless the activity causing them are modified or stopped.

Fry, Hunter J. H. "How to Treat Overuse Injury: Medicine for Your Practice." ***Music Educator's Journal*** **(May, 1986): 46-49.**

Overuse injury is explained to the music teacher in this article. Fry discusses how to measure the severity of an injury, as well as how such injuries are treated. He stresses developing an energy efficient technique and emphasizes the importance of educating music students about overuse in order prevent the root cause of such injuries.

Guy, Larry. ***Hand & Finger Development for Clarinetists.*** **Stony Point, NY: Rivernote Press, 2007.**

One of a series of pedagogical handbooks on clarinet playing by this author, this book is a well illustrated treatise on hand and finger development. There are strengthening exercises for the hand and numerous musical examples. It contains many quotes from legendary clarinet instructors. There is no bibliography.

Hansen, John T. ***Netter's Anatomy Coloring Book.*** **Philadelphia: Saunders Elesevier, Inc., 2010.**

Based upon the exquisite anatomical illustrations by FrankH. Netter, M.D., this book approaches the study of anatomy in a systematic and fun manner. The approach is one of active learning by coloring the plates presented in the book. Human anatomy is presented by body system. References are given throughout to the actual plates in Netter's *Atlas of Human Anatomy* to allow further study and review. Each book contains a code to allow access to a website where all the plates may be downloaded.

Heming, M.J.E. "Occupational Injuries Suffered by Classical Musicians Through Overuse." ***Clinical Chiropractic*** **7 (2004): 55-66.**

In this study, 70% of the musicians completing questionnaires reported having suffered an instrument-related injury at some point during their careers. Heming observed a n overall lack of awareness on the part of musicians of the benefits of good posture, ergonomics, and exercise. Education of musicians is emphasized.

Hoppmann, R.A. "Instrumental Musicians' Hazards." ***Occupational Medicine: State of the Art Reviews*** **16, no. 4, (2001): 619-631.**

This article targets the practitioner treating musicians. In addition to summaries of various injuries most likely to occur in musicians, the clinician is advised on how to obtain a detailed practice/performance history. The importance of working with the music teacher in order to scrutinize technique and address issues that may be contributing to injury is stressed. Further research and education in the area of prevention is encouraged.

Hoppmann, Richard A. " Musculoskeletal Problems in Instrumental Musicians." in ***Performing Arts Medicine*****, by Robert Thayer Sataloff, Alice G. Brandfonbrenner and Richard J. Lederman, 205-229. San Diego: Singular Publishing Group, Inc., 1998.**

Although intended primarily for the clinician, this chapter contains a number of topics that should be of interest to the performer. The section on obtaining a history from the patient contains a wealth of information concerning practicing that most instrumentalists are likely to find of interest. There is a good overview of osteoarthritis as well as overuse syndrome.

Horvath, Janet. *Playing (Less) Hurt: An Injury Prevention Guide for Musicians.* Eau Claire, WI: Janet Horvath, 2009.

Divided into three sections, this book discusses a variety of injuries, how they can occur, and preventative and rehabilitative strategies. There are numerous exercises and stretches, as well as advice on seating, hearing protection, and tips for the travelling musician. Written in an informal, engaging style, the book concludes with an extensive list of resources.

Lederman, Richard J. "Neuromuscular and Musculoskeletal Problems in Instrumental Musicians." *Muscle & Nerve* 27, (2003): 549-561.

Drawing from his personal experience of having evaluated 1353 instrumental musicians, Lederman concludes that each group of instrumentalists, such as woodwind players, tends to exhibit symptoms directly related to the static and dynamic forces placed upon them when playing their instruments. He asserts that inefficient posture, excessive tension, and extraneous movement may eventually lead to breakdown of the neuromuscular system. He notes that the right hand and thumb are the most frequent sites of pain among clarinetists. Peripheral nerve disorders and focal dystonias are also discussed, with a thorough discussion of treating musicians as patients. There is a extensive bibliography.

Lockwood, Alan H. "Medical problems of musicians." *New England Journal of Medicine* 320 (1989): 221-227.

Overuse injuries in musicians is the focus of this article, although neural impingement, focal dystonias, and psychological stress are also addressed. Lockwood feels that the most important predisposing factor in developing such injuries is the use of repetitive movements over long hours of practice, but also acknowledges the contribution of awkward body positions and technically challenging repertoire. Noting that nearly half of high school musicians report symptoms of overuse injury, Lockwood emphasizes a need for more attention to strength training for young musicians.

Markison, Robert E. "Tendinitis and related inflammatory conditions seen in musicians." *Journal of Hand Therapy* (Apr.-Jun. 1992): 80-83.

Markison feels that professionals caring for injured musicians need to get musicians "in touch with their hands as remarkable instruments in and of themselves." He discusses some instrument-specific inflammatory conditions as well as their treatments. His discussion of redesigning musical instruments contains some fairly radical ideas.

Marrero, Ian C., Jorge I. de la Torre, Bunyamin Sahin, and Bradon J. Wilhelmi. "Hand, Anatomy." ***emedicine.medscape.com.*** **December 9, 2007. http://emedicine.medscape.com/article/128506-print (accessed December 18, 2008).**
A very nice discussion of the anatomy of the hand, this article includes color photos of the skeleton and surface anatomy of the hand. These are followed by photos of dissections of the hand illustrating subcutaneous structures, muscles and tendons, and palmar structures.

McMinn, R.M.H., and R.T. Hutchings. ***Color Atlas of Human Anatomy.*** **Chicago: Year Book Medical Publishers, Inc., 1977.**
Consisting of beautiful color photos of meticulous cadaveric dissections, this book is really a work of art. Anyone with an interest in human anatomy will find this book to be an incredible resource.

Norris, Richard N., and Jan Dommerholt. "Chapter 11 Applied Ergonomics: Adaptive Equipment and Instrument Modification for Musicians." In ***Performing Arts Medicine*****, by Robert Thayer Sataloff, Alice G. Brandfonbrenner and Richard J. Lederman, 261-275. San Diego: Singular Publishing Group, Inc., 1998.**
This well-illustrated chapter describes a number of modifications that have been made to various instruments in order to make them more ergonomically sound. A number of devices to decrease static loading of instruments are also described.

Ostwald, Peter F.; Baron,Barry C.; Byl, Nancy M.; Wilson, Frank R. "Performing Arts Medicine." ***Western Journal of Medicine*** **160 (1994): 48-52.**
This article focuses on patterns of illness affecting performing artists and how health care teams can best treat them. It is felt that a multidisciplinary team of physicians and other health care professionals is really necessary to address the scope of maladies occurring among performing artists. The musician's teacher or coach should be a part of any such team.

Parry, C.B. Wynn. "Prevention of Musicians' Hand Problems." ***Hand Clinics*** **19 (2003): 317-324.**
Following a discussion of focal dystonia in musicians, Parry looks a number of musical instruments and describes various conditions and their causations in players of those instruments. He emphasizes the importance of sound technique and sensible practice schedules. He also suggests that many music students do not receive adequate instruction in posture, practice techniques, and care of the body.

Paull, Barbara: Harrison, Christine. ***The Athletic Musician: A Guide to Playing Without Pain.*** **Lantham, MD: Scarecrow Press, 1997.**
This book provides a guide to anatomy, posture, and various injuries sustained by musicians. The primary focus is on prevention, but treatment regimens for many injuries are discussed. The chapter devoted to *Arm, Wrist and Hand* lacks any significant discussion of the anatomy and biomechanics of the wrist or hand.

Pino, David. "The Clarinet Teaching of Kieth Stein, Part Seven: More on Hand Position and Finger Action." ***The Clarinet*** **31 (Jun. 2004): 82-86.**

One of a series of articles by David Pino based on materials by Kieth Stein that were intended to be made into a guide on clarinet playing for individuals with no access to a teacher. This article focuses on finger action. Movement should come from the knuckle and fingers should maintain a slight curve in each finger joint. A number of exercises are included. Hand and finger anatomy are not addressed.

Pino, David. "The Clarinet Teaching of Kieth Stein, Part Six: Hand Position and Finger Action." ***The Clarinet*** **31 (Mar. 2004): 38-41.**

One of a series of articles by David Pino based on materials by Kieth Stein that were intended to be made into a guide on clarinet playing for individuals with no access to a teacher. Position of the hands, wrists, and fingers is described in great detail, even though the actual anatomy of the hand is not addressed. Players are advised that movement of the fingers should come from the knuckles.

Poritsky, Ray. ***Hand and Upper Extremity Anatomy to Color and Study.*** **Philadelphia: Hanley & Belfus, Inc., 2000.**

With seventy -seven plates representing various levels of dissection and different aspects of upper limb anatomy, this is actually quite a comprehensive guide. The activity of coloring the plates makes the study of the anatomy more interactive and adds interest to a topic that some might find dull. Because they are based upon a much earlier text, some of the plates lack clarity.

Potter, Patrick J.; Jones, Ian C. "Medical Problems Affecting Musicians." ***Canadian Family Physician*** **41 (Dec. 1995): 2121-2128.**

Five case reports of musicians with various injuries and conditions are presented. Symptoms, evaluation, and treatment are discussed. The authors conclude that creating an understanding of the ergonomics of performance is an important part of educating musicians.

Ridenour, W. Thomas. ***The Educator's Guide to the Clarinet.*** **Duncanville, TX: W. Thomas Ridenour, 2002.**

An excellent resource, especially for non-clarinetists who find themselves involved in teaching clarinet, this describes most aspects of clarinet playing. The chapter devoted to *Finger Fundamentals* advises a natural hand position, maintaining relaxed finger curvature while playing the clarinet. There is no discussion of the anatomy of the hand or the ergonomics of playing. The section on reed adjustment is of great value to any clarinetist.

Russianoff, Leon. ***Clarinet Method, Book I.*** **New York: Schirmer Books, 1982.**

Organized as a series of lessons, Russianoff's *Method* covers nearly every aspect of clarinet playing in great depth. Each chapter is a lesson consisting of didactics, exercises to sing and count aloud, and concluding with examples from classic clarinet literature, both solo and orchestral, as well as etudes. While hand position is described, there is no discussion of anatomy. Unfortunately this book is no longer available in print.

Sharp, G., Thompson, D. "Biomechanics of the hand." ***Control of Human Movement I & II.*** **November 27, 2001. http://moon.ouhsc.edu/dthompso/namics/hand.htm (accessed December 18, 2008).**

An online discussion of the biomechanics of the hand, this article provides a concise outline of types of grasp, arches of the hand, and functional position of the hand. The mechanisms of finger flexion and extension are explained.

Spahn, C., Hildebrandt H., and Seidenglanz. "Effectiveness of a Prophylactic Course to Prevent Playing-related Health Problems of Musicians." ***Medical Problems of Performing Artists*** **16 (Mar. 2001): 24-31.**

In this frequently cited article, Spahn, et. al., evaluate the effectiveness of a weekly course, "Physiology of Music and Performing Arts," offered at the Zurich Conservatory. The course included topics such as posture, breathing, psychological factors, and playing-related symptoms. In contrast with the control group, students participating in the course reported improvements in playing-related symptoms, anxiety levels, and general coping skills, while the frequency of symptoms decreased. Linking of prophylaxis and musical pedagogy seems to beneficial. It is suggested that this sort of course be integrated into the curriculum of music schools so that a strong primary prophylactic effect may be created.

Stein, Kieth. ***The Art of Clarinet Playing.*** **Van-Nuys: Summy-Birchard Inc., (Dist. Alfred Publishing Co., Inc), pg. 29., n.d.**

Considered one of the masters of clarinet pedagogy, Kieth Stein summarizes the approaches to teaching that he so successfully employed during his forty-one year career at Michigan State University. Fundamentals are emphasized throughout. Hand position is explained, and there are photos of the correct position as well as incorrect positions for comparison. There are no anatomical descriptions. There is no bibliography.

Storm, Seneca A. "Assessing the Instrumentalist Interface: Modifications, Ergonomics and Maintenance of Play." ***Physical Medicine and Rehabilitation Clinics of North America*** **17 (2006): 893-903.**

Looking at the musician-instrument interface, this article addresses posture and musculoskeletal complaints, size and support of the instrument, as well as instrument maintenance. Storm notes that many instruments are played at the end range of motion of a joint with a resultant increase in musculoskeletal loading. Static loading of the right thumb of clarinetists is discussed. Joint hypermobility is addressed. There is a brief section on adaptive aids for musicians with disabilities.

Taylor, C.L., Schwartz, R.J. "The anatomy and mechanics of the human hand." 1955. http://www.oandplibrary.org/al/pdf/1955_02_022.pdf (accessed December 18, 2009).
This is a very nice review of the structure of the hand and how it works. The text is easy to follow. The anatomical drawings, though quite clear, are labeled with abbreviations described in tables that appear early in the article. The reader who is not already familiar with the anatomy of the hand must frequently refer to these tables in order to understand the figures.

Thomas, Earl. "Anatomical Essentials in Clarinet Hand Position." *The Clarinet* 20 (May-Jun. 1993): 18-21.
This is actually an interesting case study of a clarinetist who developed focal dystonia. There follows a discussion of right hand position in clarinet playing. No anatomical drawings or descriptions are included, thus some of the author's descriptions are rather ambiguous. The article contains a brief annotated bibliography as well as several endnotes.

Thrasher, Michael; Chesky, Kris S. "Medical Problems of Clarinetists: Results from the UNT Musician Health Survey." *Texas Music Education Research* (1998):69-75.
Based upon their survey of 324 musicians who listed the clarinet as their primary, secondary, or tertiary instruments, these authors report that the right hand and wrist were the most commonly reported sites of musculoskeletal problems with nearly 40% of subjects reporting a problem in this area. Overall, problems on the right side of the body were more frequent with women reporting more problems than men. The authors feel that an understanding of the medical problems of musicians should play an important role in developing health-conscious pedagogy as well as effective clinical intervention.

Toledo, S.D.; Nadler, S.F.; Norris, R.N.; et. al,. "Sports and Performing Arts Medicine. 5. Issues Relating to Musicians." *Archives of Physical Medicine and Rehabilitation"* 85 Suppl 1, (March 2004): S72-S74.
Actually a brief self-instruction module intended for practitioners and trainees in physiatry, this article discusses upper-limb injuries in musicians. Advising that close attention must be paid to the wrist and finger positions of musicians, the article advises that ergonomic modifications are the cornerstone of successful treatment and recovery.

Trollinger, Valerie. "Performing Arts Medicine and Music Education: What do We Really Need to Know?" *Music Educators Journal* (Nov. 2005): 42-48.
Espousing the idea that music educators are actually physical education instructors for small muscles, Tollinger feels that a basic knowledge of anatomy and performing arts medicine is necessary for music teachers. Selected resources in performing arts medicine of use to music teachers are given.

Tubiana, Raoul; Chamagne, Philippe. "Functional Anatomy of the Hand." ***Medical Problems of Performing Artists*** **(Dec. 2005): 183-187.**

A brief, but well-written, article on the functional anatomy of the hand, this contains concise descriptions of the three arches of hand. The authors point out that the position of the thumb and fingers is greatly influenced by the wrist. This is an excellent article for anyone new to the study of the hand.

University of North Texas System and the Performing Arts Medicine Association. ***Health Promotion in Schools of Music.*** **2006. http://www.unt.edu/hpsm/index.htm (accessed November 30, 2010).**

This site contains recommendations concerning the inclusion of health promotion in the curricula of music schools as supported by both the Performing Arts Medical Association and the University of North Texas.

Valdata, Lauren. "Chapter 54: Therapeutic Management of the Performing Artist." In ***Hand and Upper Extremity Rehabilitation: A Practical Guide*****, by Susan L. Burke, James Higgins and et. al., 689-705. St. Louis, MO: Elsevier Churchill Livingston, 1991.**

This chapter outlines risk-factors predisposing musicians to musculoskeletal injuries, discusses the necessity of evaluating the musician while playing the instrument, and touches upon some instrument-specific problems. In addressing treatment, emphasis is placed upon reducing unnecessary tension while playing the instrument and educating musicians on healthy practice habits. Prevention is best accomplished through instrument and postural education, stress release and improved general fitness. A questionnaire of use in obtaining a detailed history is included.

Waln, George. "How to Improve Clarinet Hand Position." ***The Instrumentalist"*** **(Jun. 1972): 42-45.**

Waln feels that hand position is a neglected fundamental of clarinet playing and that guidance should be started early in a player's career. He emphasizes that all fundamentals should be as natural and relaxed as possible . The angles of the thumbs on the clarinet are addressed. No anatomical details are given. There is no bibliography.

Warrington, Joan. "Hand Therapy for the Musician: Instrument-focused Rehabilitation." ***Hand Clinics*** **19, no. 2,(May, 2003): 287-301.**

Although the focus of this article is rehabilitation of the injured musician, it contains a wealth of information to help the healthy musician remain that way. Suggestions for strengthening hypermobile joints are given. It is advised that joint protection and energy conservation be parts of the musician's activities of daily living as well playing his/her instrument. Muscle imbalance, especially in the hands and forearms is discussed. Desirable hand posture is nicely described. Hand therapy for a number of specific conditions is discussed.

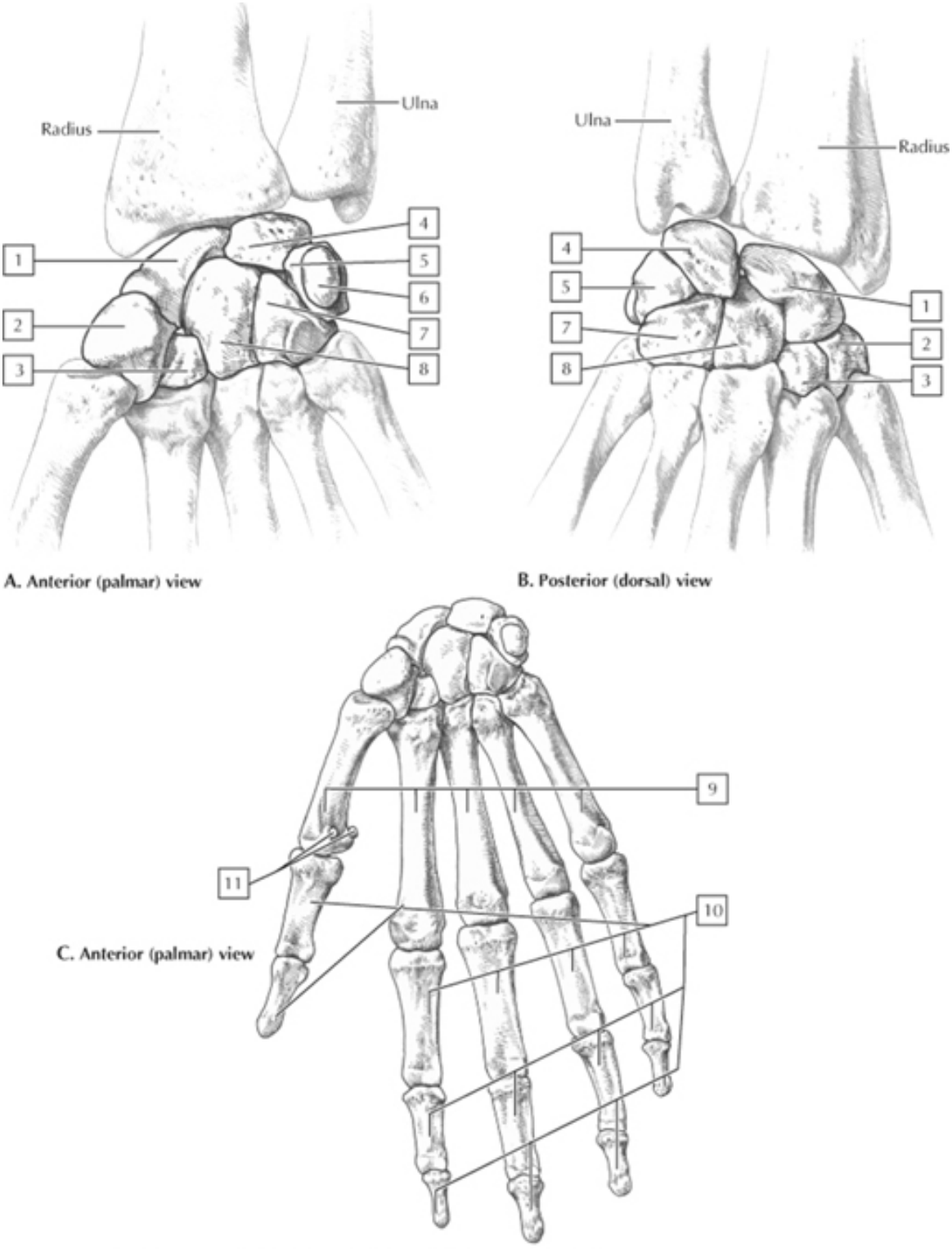
Watson, Alan H.D. *The Biology of Musical Performance.* Lanham, MD: The Scarecrow Press, Inc., 2009.

This book was designed to be used as a collegiate-level text for courses in human biology for performers. The author teaches such a course at the Royal Welsh College of Music and Drama. Wilson believes that the biology of human performance should be a core component of the curriculum of every music school. His text is written with enough detail to be challenging yet not so much that it becomes overwhelming. A CD-ROM containing illustrations and animations augments the text. Each chapter is followed by an extensive reference list.

Appendix

Plates from Netter's Anatomy Coloring Book

Plate 2-13



2 Wrist and Hand

The wrist and hand are composed of the following 29 bones:

- 8 carpal (wrist) bones, arranged in proximal and distal rows of 4 bones each
- 5 metacarpals, which span the palm of the hand
- 14 phalanges, 2 for the thumb (1st digit) and 3 each for the remaining 4 digits
- 2 sesamoid bones, situated at the distal end of the thumb metacarpal

These bones and their features are summarized in the table below.

FEATURE	CHARACTERISTICS
Proximal Row of Carpals	
Scaphoid (boat shaped)	Lies beneath anatomical snuffbox
Lunate (moon or crescent shaped)	Is most commonly fractured carpal
Triquetrum (triangular)	All three bones (scaphoid, lunate, triquetrum) articulate with distal radius
Pisiform (pea shaped)	
Distal Row of Carpals	
Trapezium (four sided)	Distal row articulates with proximal row of carpals and with metacarpals
Trapezoid	
Capitate (round bone)	
Hamate (hooked bone)	
Metacarpals	
Numbered 1-5	Possess a base, shaft, and head
(thumb to little finger)	Are triangular in cross section
	Fifth metacarpal most commonly fractured
Two sesamoid bones	Are associated with head of first metacarpal
Phalanges	
Three for each digit except thumb	Possess a base, shaft, and head
	Termed proximal, middle, and distal
	Distal phalanx of middle finger commonly fractured

The carpal bones are not aligned in a flat plane but form an arch, the **carpal arch**, with its concave aspect facing anteriorly. Tendons from forearm muscles, vessels, and nerves pass through or across this arch to gain access to the hand. A tight band of connective tissue, the flexor retinaculum, spans the carpal arch forming a "carpal tunnel" for the structures passing through this archway.

COLOR the following bones of the wrist and hand, using different colors for each carpal bone, a uniform color for the metacarpals, another uniform color for all the phalanges of the digits, and a new color for the sesamoid bones:

- ☐ **1. Scaphoid: some clinicians refer to this bone as the navicular ("little ship")**
- ☐ **2. Trapezium**
- ☐ **3. Trapezoid**
- ☐ **4. Lunate**
- ☐ **5. Triquetrum**
- ☐ **6. Pisiform**
- ☐ **7. Hamate**
- ☐ **8. Capitate**
- ☐ **9. Metacarpals**
- ☐ **10. Phalanges of each digit**
- ☐ **11. Sesamoid bones (two at the distal end of the thumb metacarpal)**

Plate 2-14

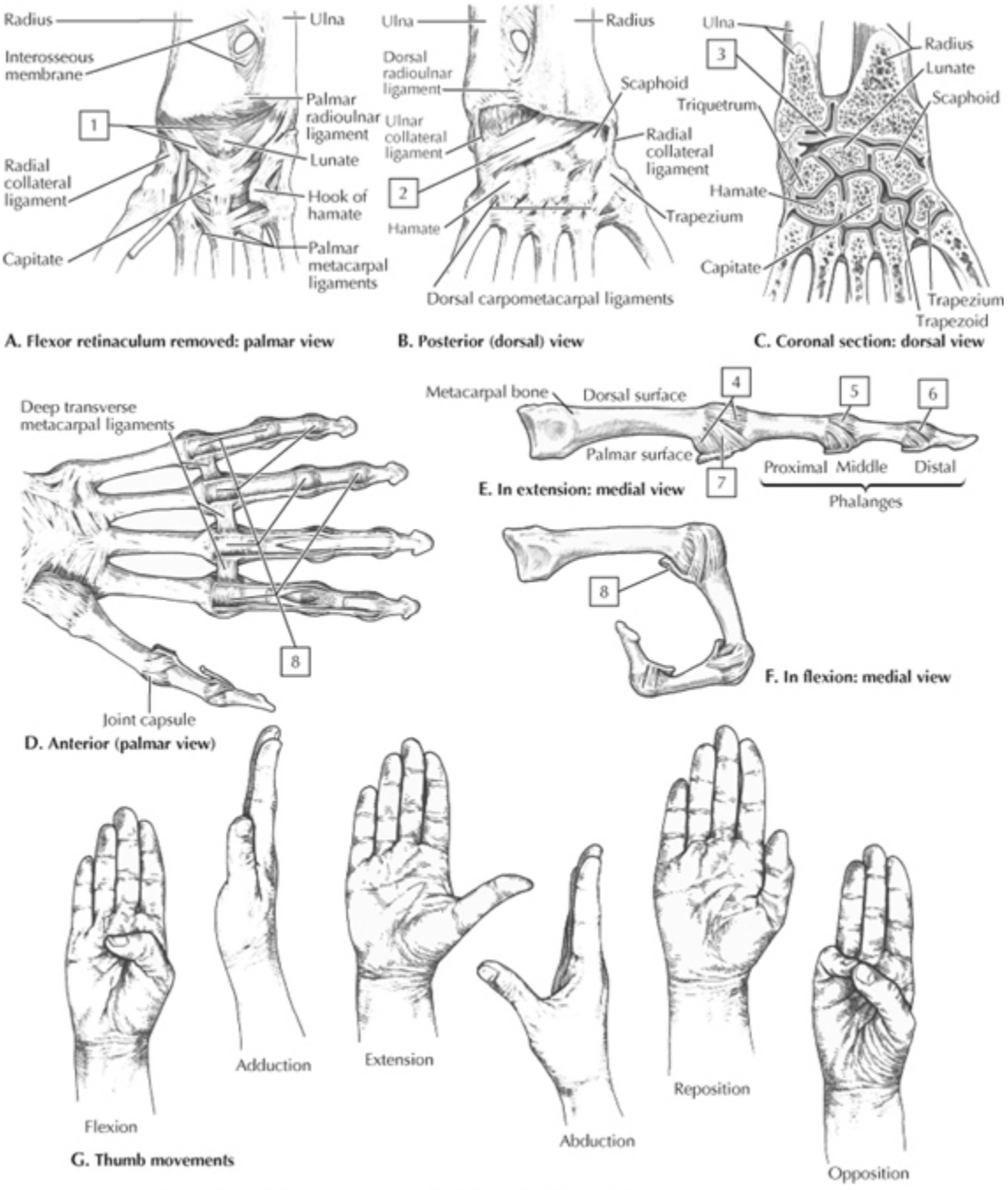


Plate 2-14

2 Wrist and Finger Joints and Movements

The classification and ligaments of the wrist and finger joints are summarized in the following table. The wrist joint is a radiocarpal (biaxial synovial ellipsoid) joint between the distal radius of the forearm and the scaphoid, lunate and triquetrum carpals, and the articular disc at the distal ulna. On the facing page, note the finger movements associated with these joints.

COLOR the following major ligaments, using a different color for each ligament:

- ☐ **1. Palmar radiocarpal ligaments**
- ☐ **2. Dorsal radiocarpal ligament**
- ☐ **3. Articular disc of the wrist joint**
- ☐ **4. Capsule of a metacarpophalangeal joint**
- ☐ **5. Capsule of a proximal interphalangeal joint**
- ☐ **6. Capsule of a distal interphalangeal joint**
- ☐ **7. Collateral ligament of a metacarpophalangeal joint**
- ☐ **8. Palmar ligament (plate)**

LIGAMENT	ATTACHMENT	COMMENT
	Radiocarpal (Biaxial Synovial Ellipsoid) Joint	
Capsule and disc	Surrounds joint; radius to scaphoid, lunate, and triquetrum	Provides little support; allows flexion, extension, abduction, adduction, circumduction
Palmar (volar) radiocarpal ligaments	Radius to scaphoid, lunate, and triquetrum	Are strong and stabilizing
Dorsal radiocarpal	Radius to scaphoid, lunate, and triquetrum	Is weaker ligament
Radial collateral	Radius to scaphoid and triquetrum	Stabilizes proximal row of carpals
	Distal Radiocarpal (Uniaxial Synovial Pivot) Joint	
Capsule	Surrounds joint; ulnar head to ulnar notch of radius	Is thin superiorly; allows pronation, supination
Palmar and dorsal radioulnar	Extends transversely between the two bones	Articular disc binds bones together
	Intercarpal (Synovial Plane) Joints	
Proximal row of carpals	Adjacent carpals	Permits gliding and sliding movements
Distal row of carpals	Adjacent carpals	Are united by anterior, posterior, and interosseous ligaments
	Midcarpal (Synovial Plane) Joints	
Palmar (volar) intercarpal	Proximal and distal rows of carpals	Is location for one third of wrist extension and two thirds of flexion; permits gliding and sliding movements
Carpal collaterals	Scaphoid, lunate, and triquetrum to capitate and hamate	Stabilize distal row (ellipsoid synovial joint)
	Carpometacarpal (CMC) (Plane Synovial) Joints (Except Thumb)	
Capsule	Carpals to metacarpals of digits 2-5	Surrounds joints; allows some gliding movement
Palmar and dorsal CMC	Carpals to metacarpals of digits 2-5	Dorsal ligament strongest
Interosseous CMC	Carpals to metacarpals of digits 2-5	
	Thumb (Biaxial Saddle) Joint	
Same ligaments as CMC	Trapezium to first metacarpal	Allows flexion, extension, abduction, adduction, circumduction
		Is common site for arthritis
	Metacarpophalangeal (Biaxial Condyloid Synovial) Joint	
Capsule	Metacarpal to proximal phalanx	Surrounds joint; allows flexion, extension, abduction, adduction, circumduction
Radial and ulnar collaterals	Metacarpal to proximal phalanx	Are tight in flexion and loose in extension
Palmar (volar) plate	Metacarpal to proximal phalanx	If broken digit, cast in flexion or ligament will shorten during healing
	Interphalangeal (Uniaxial Synovial Hinge) Joints	
Capsule	Adjacent phalanges	Surrounds joints; allows flexion and extension
Two collaterals	Adjacent phalanges	Are oriented obliquely
Palmar (volar) plate	Adjacent phalanges	Prevents hyperextension

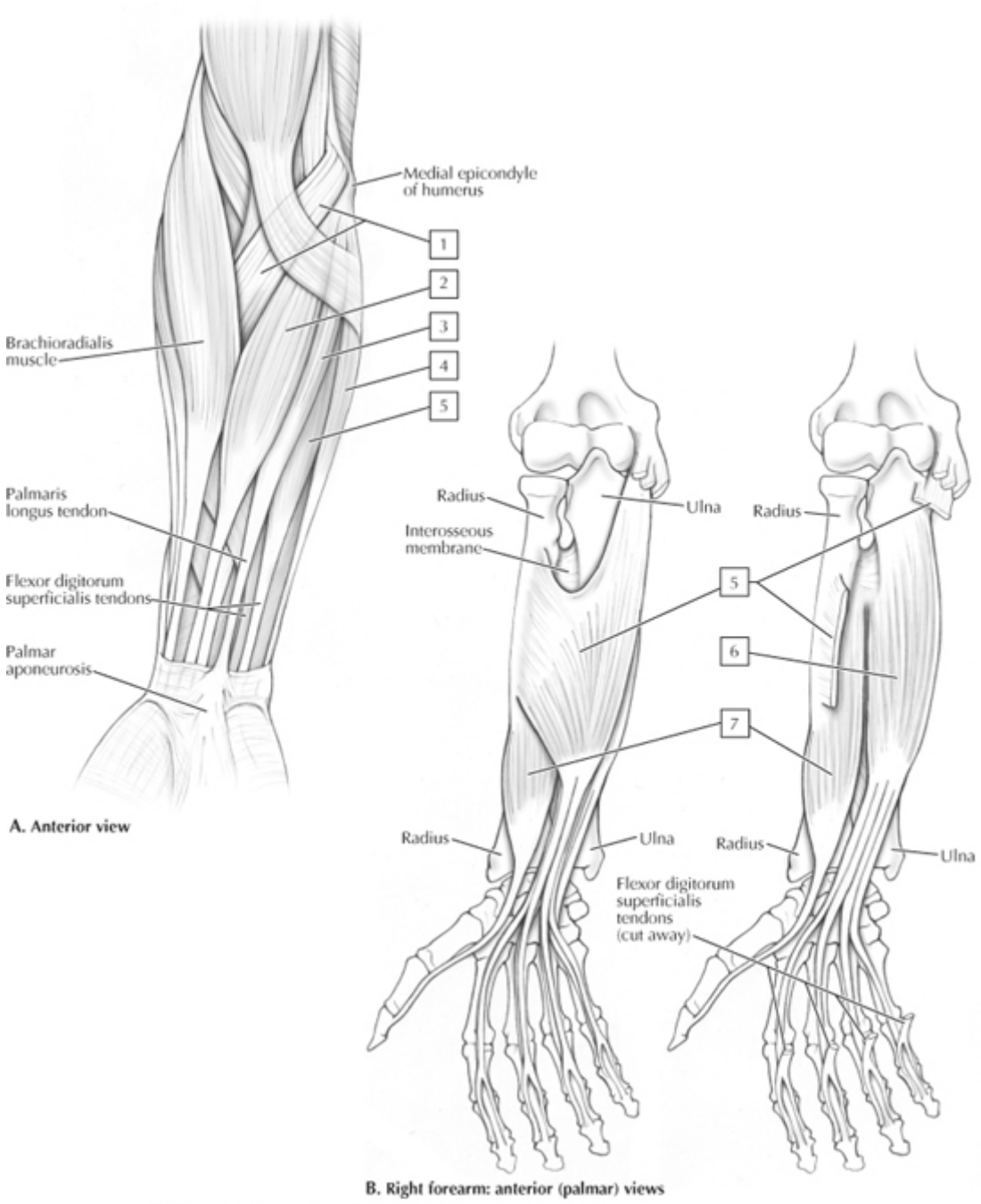


Plate 3-21

Plate 3-21

3 Anterior Forearm Muscles

The forearm is divided into two muscle compartments by a connective tissue intermuscular septum. The anterior compartment contains muscles that primarily flex the wrist and fingers. In the anterior compartment, a superficial layer of muscles arises from the medial epicondyle of the humerus, whereas a deep layer of muscles arises from the bones (radius and ulna) of the forearm or the interosseous membrane connecting these bones. If you squeeze your hand very tightly to make a fist and flex your wrist, you will note the contraction of these muscles in your own anterior forearm. These muscles are summarized in the table below.

COLOR each of the following muscles, using a different color for each muscle:

- ☐ **1. Pronator teres**
- ☐ **2. Flexor carpi radialis (also abducts the wrist)**
- ☐ **3. Palmaris longus: absent in about 10% of humans, this muscle is of little importance in us but is the muscle in cats that allows them to retract their claws**
- ☐ **4. Flexor carpi ulnaris (also adducts the wrist)**
- ☐ **5. Flexor digitorum superficialis**
- ☐ **6. Flexor digitorum profundus: "profundus" means deep as in a profound comment**
- ☐ **7. Flexor pollicis longus: "pollicis" refers to the thumb**

MUSCLE	PROXIMAL ATTACHMENT (ORIGIN)	DISTAL ATTACHMENT (INSERTION)	INNERVATION	MAIN ACTIONS
Pronator teres	Medial epicondyle of humerus and coronoid process of ulna	Middle of lateral surface of radius	Median nerve (C6, C7)	Pronates forearm and flexes elbow
Flexor carpi radialis	Medial epicondyle of humerus	Base of 2nd metacarpal bone	Median nerve (C6, C7)	Flexes hand at wrist and abducts it
Palmaris longus	Medial epicondyle of humerus	Distal half of flexor retinaculum and palmar aponeurosis	Median nerve (C7, C8)	Flexes hand at wrist and tightens palmar aponeurosis
Flexor carpi ulnaris	*Humeral head:* medial epicondyle of humerus *Ulnar head:* olecranon and posterior border of ulna	Pisiform bone, hook of hamate bone, and 5th metacarpal bone	Ulnar nerve (C7-C8 and T1)	Flexes hand at wrist and adducts it
Flexor digitorum superficialis	*Humeroulnar head:* medial epicondyle of humerus, ulnar collateral ligament, and coronoid process of ulna *Radial head:* superior half of anterior radius	Bodies of middle phalanges of medial four digits on the palmar aspect	Median nerve (C8-T1)	Flexes middle phalanges of medial four digits; also weakly flexes proximal phalanges, forearm, and wrist
Flexor digitorum profundus	Proximal three fourths of medial and anterior surfaces of ulna and interosseous membrane	Bases of distal phalanges of medial four digits on the palmar aspect	*Medial part:* ulnar nerve (C8-T1) *Lateral part:* median nerve (C8-T1)	Flexes distal phalanges of medial four digits; assists with flexion of wrist
Flexus pollicis longus	Anterior surface of radius and adjacent interosseous membrane	Base of distal phalanx of thumb on the palmar aspect	Median nerve (anterior interosseous) (C7-C8)	Flexes phalanges of 1st digit (thumb)
Pronator quadratus	Distal fourth of anterior surface of ulna	Distal fourth of anterior surface of radius	Median nerve (anterior interosseous) (C7-C8)	Pronates forearm

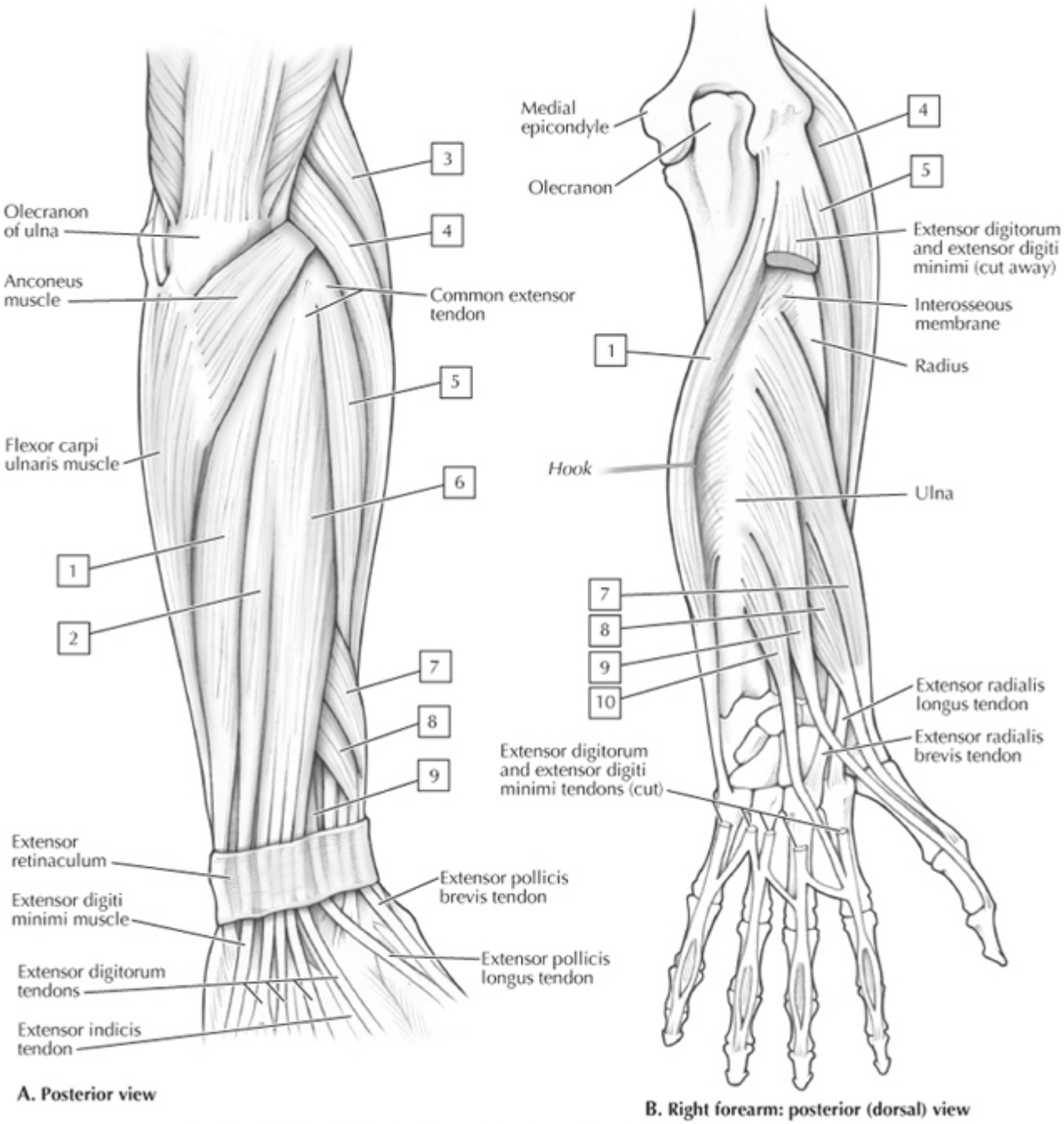


Plate 3-22

3 Posterior Forearm Muscles

The forearm is divided into two muscle compartments by a connective tissue intermuscular septum. The posterior compartment contains muscles that primarily extend the wrist and fingers. In the posterior compartment, a superficial layer of muscles arises largely from the lateral epicondyle of the humerus, whereas a deep layer of muscles arises from the bones of the forearm (radius and ulna) or the interosseous membrane connecting these bones. If you hyperextend your fingers and wrist and pronate your forearm, you will note the contraction of these muscles in your own posterior forearm. Extending the wrist when gripping an object adds extra strength to our grip (the power grip). These muscles are summarized in the table below.

MUSCLE	PROXIMAL ATTACHMENT (ORIGIN)	DISTAL ATTACHMENT (INSERTION)	INNERVATION	MAIN ACTIONS
Brachioradialis	Proximal two thirds of lateral supracondylar ridge of humerus	Lateral surface of distal end of radius	Radial nerve (C5-C6)	Flexes forearm at elbow, especially in midpronation
Extensor carpi radialis longus	Lateral supracondylar ridge of humerus	Base of second metacarpal bone	Radial nerve (C6-C7)	Extends and abducts hand at wrist
Extensor carpi radialis brevis	Lateral epicondyle of humerus	Base of 3rd metacarpal bone	Radial nerve (deep branch) (C7-C8)	Extends and abducts hand at wrist
Extensor digitorum	Lateral epicondyle of humerus	Extensor expansions of medial four digits	Radial nerve (posterior interosseous) (C7-C8)	Extends medial four digits at metacarpophalangeal joints; extends hand at wrist joint
Extensor digiti minimi	Lateral epicondyle of humerus	Extensor expansion of 5th digit	Radial nerve (posterior interosseous) (C7-C8)	Extends 5th digit at metacarpophalangeal and interphalangeal joints
Extensor carpi ulnaris	Lateral epicondyle of humerus and posterior border of ulna	Base of 5th metacarpal bone	Radial nerve (posterior interosseous) (C7-C8)	Extends and adducts hand at wrist
Supinator	Lateral epicondyle of humerus; radial collateral, and anular ligaments; supinator fossa; and crest of ulna	Lateral, posterior, and anterior surfaces of proximal third of radius	Radial nerve (deep branch) (C6-C7)	Supinates forearm
Abductor pollicis longus	Posterior surfaces of ulna, radius, and interosseous membrane	Base of 1st metacarpal bone on the lateral aspect	Radial nerve (posterior interosseous) (C7-C8)	Abducts thumb and extends it at carpometacarpal joint
Extensor pollicis brevis	Posterior surfaces of radius and interosseous membrane	Base of proximal phalanx of thumb on the dorsal aspect	Radial nerve (posterior interosseous) (C7-C8)	Extends proximal phalanx of thumb at carpometacarpal joint
Extensor pollicis longus	Posterior surface of middle third of ulna and interosseous membrane	Base of distal phalanx of thumb on the dorsal aspect	Radial nerve (posterior interosseous) (C7-C8)	Extends distal phalanx of thumb at metacarpophalangeal and interphalangeal joints
Extensor indicis	Posterior surface of ulna and interosseous membrane	Extensor expansion of second digit	Radial nerve (posterior interosseous) (C7-C8)	Extends second digit and helps extend hand at wrist

COLOR each of the following muscles, using a different color for each muscle:

- ☐ **1. Extensor carpi ulnaris (also adducts the wrist)**
- ☐ **2. Extensor digiti minimi ("minimi" refers to the little finger)**
- ☐ **3. Brachioradialis: lumped with the posterior forearm muscles because of its innervation, it actually flexes the forearm at the elbow**
- ☐ **4. Extensor carpi radialis longus (also abducts the wrist; important in power grip)**
- ☐ **5. Extensor carpi radialis brevis (also abducts the wrist; important in power grip)**
- ☐ **6. Extensor digitorum**
- ☐ **7. Abductor pollicis longus ("pollicis" refers to the thumb)**
- ☐ **8. Extensor pollicis brevis**
- ☐ **9. Extensor pollicis longus**
- ☐ **10. Extensor indicis ("indicis" refers to the index finger)**

Clinical Note:
"Tennis elbow" is a condition that clinicians call lateral epicondylitis, which itself is a somewhat misleading diagnosis because the problem really involves a tendinosis of the extensor carpi radialis brevis (probably the most important wrist extensor), which arises just proximal to this epicondyle. Moreover, most sufferers are not tennis players! The elbow pain experienced in tennis elbow occurs just distal and posterior to the lateral epicondyle and is exacerbated during wrist extension, especially against resistance. The pain may be due to the muscle, its innervating nerve, and/or something within the elbow joint itself.

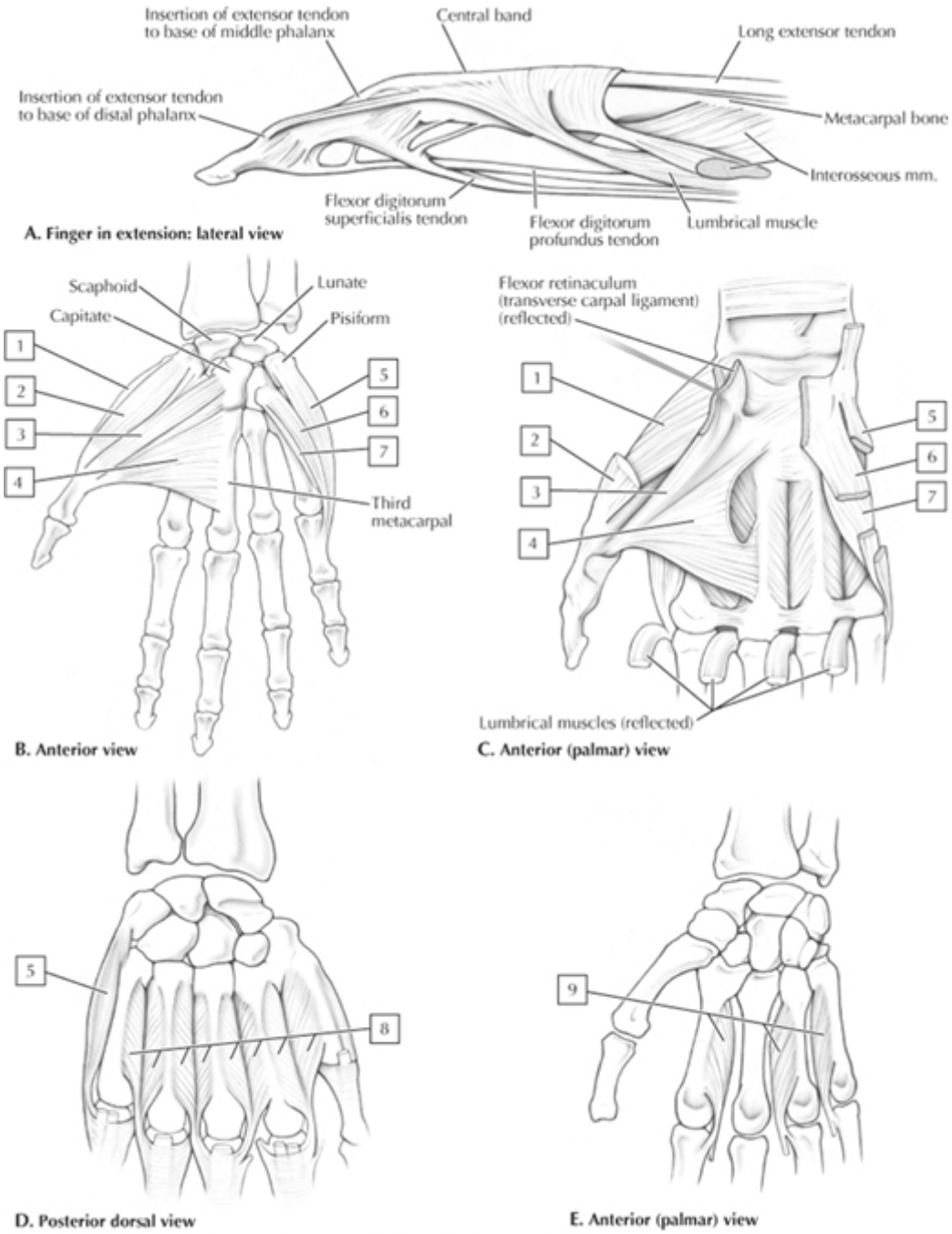


Plate 3-23

3 Intrinsic Hand Muscles

The intrinsic hand muscles move the fingers, complementing the long flexor and extensor forearm muscles that also move the fingers. Two groups of muscle lie most superficial:

- Thenar eminence: a cone of three thenar muscles at the base of the thumb
- Hypothenar eminence: a cone of three hypothenar muscles at the base of the little finger

Deeper intrinsic muscles include the:

- Adductor pollicis: deep in the palm, it adducts the thumb
- Lumbricals: four small muscles attached to the flexor digitorum profundus tendons
- Interossei: three palmar and four dorsal interosseous muscles between the metacarpals; palmar interossei adduct the digits (PAD) and dorsal interossei abduct the digits (DAB)

COLOR each of the following muscles, using a different color for each muscle:

- ☐ **1. Opponens pollicis (thenar muscle)**
- ☐ **2. Abductor pollicis brevis (thenar muscle)**
- ☐ **3. Flexor pollicis brevis (thenar muscle)**
- ☐ **4. Adductor pollicis**
- ☐ **5. Abductor digiti minimi (hypothenar muscle)**
- ☐ **6. Flexor digiti minimi (hypothenar muscle)**
- ☐ **7. Opponens digiti minimi (hypothenar muscle)**
- ☐ **8. Dorsal interossei**
- ☐ **9. Palmar interossei**

These intrinsic muscles are summarized in the table below.

MUSCLE	PROXIMAL ATTACHMENT (ORIGIN)	DISTAL ATTACHMENT (INSERTION)	INNERVATION	MAIN ACTIONS
Abductor pollicis brevis	Flexor retinaculum and tubercles of scaphoid and trapezium	Lateral side of base of proximal phalanx of thumb	Median nerve (recurrent branch) (C8-T1)	Abducts thumb at metacarpophalangeal joint
Flexor pollicis brevis	Flexor retinaculum and tubercle of trapezium	Lateral side of base of proximal phalanx of thumb	Median nerve (recurrent branch) (C8-T1)	Flexes proximal phalanx of thumb
Opponens pollicis	Flexor retinaculum and tubercle of trapezium	Lateral side of first metacarpal bone	Median nerve (recurrent branch) (C8-T1)	Opposes thumb toward center of palm and rotates it medially
Adductor pollicis	*Oblique head:* bases of 2nd and 3rd metacarpals and capitate *Transverse head:* anterior surface of body of 3rd metacarpal bone	Medial side of base of proximal phalanx of thumb	Ulnar nerve (deep branch) (C8-T1)	Adducts thumb toward middle digit
Abductor digiti minimi	Pisiform and tendon of flexor carpi ulnaris	Medial side of base of proximal phalanx of 5th digit	Ulnar nerve (deep branch) (C8-T1)	Abducts 5th digit
Flexor digiti minimi brevis	Hook of hamate and flexor retinaculum	Medial side of base of proximal phalanx of 5th digit	Ulnar nerve (deep branch) (C8-T1)	Flexes proximal phalanx of 5th digit
Opponens digiti minimi	Hook of hamate and flexor retinaculum	Palmar surface of 5th metacarpal bone	Ulnar nerve (deep branch) (C8-T1)	Draws 5th metacarpal bone anteriorly and rotates it, bringing it into opposition with thumb
Lumbricals 1 and 2	Lateral two tendons of flexor digitorum profundus	Lateral sides of extensor expansions of 2nd to 5th digits	Median nerve (C8-T1)	Flex digits at metacarpophalangeal joints and extend interphalangeal joints
Lumbricals 3 and 4	Medial three tendons of flexor digitorum profundus	Lateral sides of extensor expansions of 2nd to 5th digits	Ulnar nerve (deep branch) (C8-T1)	Flex digits at metacarpophalangeal joints and extend interphalangeal joints
Dorsal interossei	Adjacent sides of two metacarpal bones	Extensor expansions and bases of proximal phalanges of 2nd to 4th digits	Ulnar nerve (deep branch) (C8-T1)	Dorsal interossei abduct digits; flex digits at metacarpophalangeal joint and extend interphalangeal joints
Palmar interossei	Palmar surfaces of 2nd, 4th, and 5th metacarpal bones	Extensor expansions of digits and bases of proximal phalanges of 2nd, 4th, and 5th digits	Ulnar nerve (deep branch) (C8-T1)	Palmar interossei adduct digits; flex digits at metacarpophalangeal joint and extend interphalangeal joints