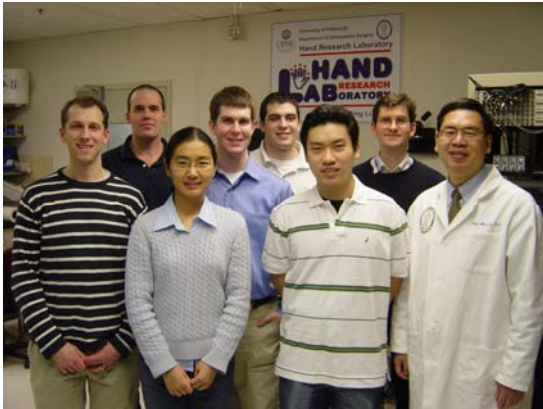


Hand Research Laboratory

Zong-Ming Li, PhD



<http://www.pitt.edu/~zmli/handlab/>

Carpal tunnel syndrome is the most common peripheral entrapment neuropathy and has an immense impact on quality of life, worker productivity, and national health care. Motivated by the astounding prevalence and public health cost of carpal tunnel syndrome, Zong-Ming Li, PhD, directs the Hand Research Laboratory, and leads a research team to study carpal tunnel syndrome using a bioengineering approach.

The totality of our laboratory team brings together expertise in orthopaedics, biomechanics, engineering, kinesiology, motor control, biology, neurology, and occupational therapy. Our attending hand surgeons, Robert J. Goitz, MD and Robert A. Kaufmann, MD, provide clinical support to our research activities. Nancy Baker, DSc, OTR/L provides guidance in the area of occupational therapy. Ms. Jie Tang, a Research Engineer, plays a versatile role in supporting the technical development of several projects, as well as coordinating the daily functioning of the lab. Corey A. Pacek, MD, an Orthopaedic resident, joined our group last July to spend a year working in the lab. Since his arrival in our lab, he has been performing a series of innovative anatomical studies on the transverse carpal ligament and carpal tunnel. Sebastian Gehrmann, MD, an orthopaedic resident from Duesseldorf, Germany, joined our lab as a research fellow last September and focuses on the functional impairment of hand and fingers associated with carpal tunnel syndrome. Mr. Eric James and Mr. Chirag Chauhan, while

attending medical school, continue to work on their Scholarly Projects with our laboratory. Two other medical students, Mr. Kraig Graham and Mr. Philip McClure, have joined our lab and are studying the morphology and pathology of the distal interphalangeal joint. In addition, four undergraduate engineering students, Mr. Matthew Chakan, Mr. Luke Xie, Mr. Jeremy Bock, and Mr. Nicholas Werner, enthusiastically work in the laboratory on various hand projects. Together, this plethora of talent boosts the momentum of our research excellence.

In several recent clinical projects, the motor manifestations of carpal tunnel syndrome were examined by monitoring the complex motion patterns of the thumb using a camera motion analysis system. The results supported the hypothesis that carpal tunnel syndrome preferentially impairs abduction and pronation at the carpometacarpal joint. The functional consequences of median neuropathy during precision grip, precision pinch movements, and thumb force production were also studied using simulated neuropathy achieved by blocking the lower median nerve. To further understand the underlying muscular mechanisms for the observed motion abnormalities, cadaveric hands were used to elucidate thumb kinematics generated by individual thumb muscles.

Commonly, carpal tunnel syndrome patients experience tightness of intrinsic hand muscles. Our laboratory developed a robot-assisted methodology to investigate the regulation of the intrinsic muscles on the stiffness of the proximal interphalangeal joint of the index finger. Torque-angle data of the proximal interphalangeal joint with the different flexion angles at the metacarpophalangeal joint were obtained from human subjects. The dependence of proximal interphalangeal joint stiffness on the metacarpophalangeal joint position supports the regulatory role of the intrinsic muscles on finger joint mechanics. This regulatory mechanism is likely amplified in hands with intrinsic muscle tightness, justifying the commonly used Bunnell Intrinsic Tightness Test.

The transverse carpal ligament has essential relevance to carpal tunnel syndrome. It is hypothesized that the hypertrophy of the ligament is a potential etiological factor for carpal tunnel syndrome. Also, the transverse carpal ligament is the target for standard surgical treatment of carpal tunnel syndrome for almost a century. However, our knowledge of the ligament is scarce. We are studying the morphological properties of the ligament as well as the carpal tunnel by digitization on cadaveric specimens and 3D computer reconstruction.

Our research team is studying the expandability of the carpal tunnel by stretching the transverse carpal ligament as a mechanism to release carpal tunnel pressure. This work is inspired by balloon carpal tunnel plasty, a

minimally invasive surgical procedure invented by Lee Berger, MD, as an alternative treatment for carpal tunnel syndrome. In a recent experiment, cadaveric hands were dissected to expose the transverse carpal ligament with the carpal tunnel emptied. The transverse carpal ligament was stretched by a volarly directed force from within the carpal tunnel. The results of the measurements demonstrated that the carpal tunnel was indeed expandable. Potentially, the mechanical properties of the transverse carpal ligament may be exploited to develop alternative procedures to release carpal tunnel pressure.

Despite such progress, many research questions related to the carpal tunnel await investigation. For example, what are the biological mechanisms of the thickening of the transverse carpal ligament and how can we prevent the thickening process through biological intervention or ergonomic optimization? Can we design alternative surgical treatment protocols to restore optimal mechanical properties of the carpal ligament? Is there a gender difference in carpal tunnel mechanics? How does carpal tunnel mechanics evolve with age and why are middle-aged individuals most susceptible? Exploring these and other questions will lead the way to improved strategies for diagnosis, prevention, and treatment of carpal tunnel syndrome.

In addition to its focus on carpal tunnel syndrome, the research in the Hand Lab has a broader impact in generating knowledge that will facilitate improved understanding and management of various hand disorders. For example, we are investigating the wrist kinematics and its interaction with finger joints. The sub-maximal motion pattern of the wrist is also being examined. We are developing methods to evaluate the normal and pathological proprioception of finger joints. In addition, the biomechanics of mouse scrolling is being studied.

This past year our lab has continued to disseminate knowledge in hand research including peer-reviewed publications in the *Journal of Hand Surgery*, *Journal of Orthopaedic Research*, *Clinical Neurophysiology*, *Motor Control*, *Ultrasonics*, *Journal of Biomechanics*, and *Journal of Electromyography and Kinesiology*. We have also been actively presenting our research in professional conferences, including the 1st American Conference on Human Vibration, the 5th World Congress of Biomechanics, the Annual Meeting of the American Society of Biomechanics, the 1st International Conference of Chinese Orthopaedic Research Society, and the Annual Meeting of the Orthopaedic Research Society. In addition, Dr. Li was an invited Keynote speaker at the China National Biomechanics Conference in Hong Kong, China. Dr. Li was also invited to give lectures in Chongqing University Institute of Bioengineering, and Mayo Clinic

School of Medicine Department of Physiology and Biomedical Engineering.

We are enthusiastic about providing services to our profession. Dr. Li was a reviewer and a session chair for this year's meeting of the Orthopaedic Research Society. He has also been appointed as the Co-Chair of the Upper Extremity Topic Committee of Orthopaedic Research Society for a two-year term starting 2007. Dr. Li also serves as a member of the International Scientific Committee of the 6th Triennial International Hand and Wrist Biomechanics Symposium, and a member of International Scientific Advisory Committee of the International Society of Biomechanics Conference. In addition, Dr. Li is invited to be an ad hoc faculty member of the Fourth Motor Control Summer School. Recently, Dr. Li was elected as the Secretary of World Association for Chinese Biomedical Engineers, serving for a 4-year term starting 2007.

We are very grateful for our financial support through the Whitaker Foundation, the Aircast Foundation, the Pittsburgh Foundation, Freddie H. Fu, MD, DSc (Hon), DPs (Hon), David Silver Professor and Chair Funds, and our Department of Orthopaedic Surgery. Most recently, Dr. Li was honored as the first recipient of the Frank E. Raymond Memorial Research Grant from the Orthopaedic Research and Education Foundation (OREF). We are grateful for these generous supports, without which our work would not be possible. Our Hand Research Laboratory strives to achieve excellence through dedicated effort, innovative research, multidisciplinary collaboration, educational activities, and professional service.

Laboratory Personnel

Jeremy Bock, Undergraduate Student
Nancy Baker, DSc, OTR/L, Faculty in Occupational Therapy
Matthew Chakan, Undergraduate Student
Chirag Chauhan, Medical Student
Sebastian Gehrmann, MD, Visiting Research Fellow
Robert Goitz, MD, Faculty in Orthopaedic Surgery
Kraig Graham, Medical Student
Norm Gustafson, OTR/L, CHT, Faculty in Occupational Therapy
Eric James, Medical Student
Robert Kaufmann, MD, Faculty in Orthopaedic Surgery
Zong-Ming Li, PhD, Director of Hand Research Laboratory
Philip McClure, Medical Student
Corey Pacek, MD, Orthopaedic Resident
Jie Tang, MS, Research Engineer
Nicholas Werner, Undergraduate Student
Luke Xie, Undergraduate Student