Orthopedics This Week

1

Volume 3, Issue 26 | August 21, 2007

Carpal tunnel Research: A View Out of the Tunnel

By Elizabeth Hofheinz, M.P.H., M.Ed.

"We've been cutting it for nearly a century, but we really don't know much about it—the transverse carpal ligament, that is." So says Zong-Ming Li, Ph.D., associate professor in the Department of Orthopaedic Surgery and director of the Hand Research Laboratory at the University of Pittsburgh Medical Center. Dr. Li, who has recently received a National Institutes of Health (NIH) grant to study the basic biomechanical properties of the transverse carpal ligament, states, "Before we can do something else about this ligament, we need to understand it."

Carpal tunnel research itself has made a name for itself. Says Dr. Li, "Carpal tunnel syndrome has become pandemic in our modern society, begging for an elevated research effort. For the last few decades, there has been a plethora of data in the literature establishing the high prevalence of carpal tunnel syndrome. The disorder is found to be associated with a number of factors that are extrinsic such as the environment and biomechanics, and intrinsic such as diabetes and some systemic diseases. But we still do not know the exact etiology. Though researchers are gaining more insight into its mechanisms, more effort is needed."

A champion of laying solid groundwork, Dr. Li says, "Our team focuses on two aspects of carpal tunnel syndrome: hand sensorimotor function and carpal tunnel mechanics. The median nerve is said to be the eyes of the hand because it provides motor and sensory supplies to the primary digits. As such, hand dysfunction is very sensitive to median neuropathy. For example, we have done research where we injected an anesthetic drug into the carpal tunnel to block the median nerve, thus simulating severe carpal tunnel syndrome. Then we examined the functional consequences. Other studies we did involved the biomechanical consequences of carpal tunnel, such as strength, dexterity, and the precision of manipulation. We developed a battery of quantification on these measures. Dexterity has been a subjective term, but we are now developing tools to quantify it. For example, if we put sensors on the thumb and index finger and ask a patient to do precision pinching movements, our motion analysis system allows us to look into the kinematic behavior of the digits. We see that normal people can close the thumb and index finger accurately and precisely. Patients, however, have a larger variation at the tips, so the accuracy of the motion is degraded. Although this kind of study looks biomechanical, it addresses some of the neurophysiological aspects of carpal tunnel syndrome because the lack of accuracy of the pinching movement is related to the sensory and proprioceptive information of the digits. In the future we will be able to determine if conservative or surgical treatment can help restore these fine motor functions."

Delicate and nuanced, hand motions operate at a level that deserve more scrutiny. And Dr. Li has a way to approach it. "I am interested in how our neuromusculoskeletal system is controlled and have determined that sensory motor function impairment provides a good model for understanding how this system works. For example, we have information on how the thumb and index finger coordinate to produce force. When we pick up a light object, we don't use excessive force. This kind of manipulation relies on sensorimotor integration. So, if the median nerve is involved in carpal tunnel syndrome, this sensory motor loop is impaired and the hand can't function as well. That's why patients drop things and seem clumsy—they are not getting timely feedback of sensory and proprioceptive information. There may be a significantly delayed response from the peripheral fingers, for example. We are also examining how multiple fingers coordinate, something that is an extension of my Ph.D. work on finger coordination. In carpal tunnel syndrome, the fingers may not be coordinated. All fingers generate perturbation forces, i.e., the distribution of force and how fingers respond. If you hold a glass of wine the force coming from all fingers should be properly distributed. If one finger applies too much force, you've tilted the glass."

And while you probably don't give your thumb much thought, Dr. Li does. "Another study we have underway examines how the thumb's strength is affected by carpal tunnel syndrome. Normally we would think that thumb strength would be affected because several thumb muscles are innervated by the median nerve. However, we found that thumb strength is relatively preserved in carpal tunnel syndrome patients. In the old days people came to the clinic with atrophy of the thenar muscles in the thumb. Now that people with predominant sensory disturbances are more aware of this disorder, however, they approach care earlier on. This is a good thing because then the muscles' force generating capability is more preserved. Still, this doesn't mean that motor function is not impaired. When the hand performs manipulation tasks, it's not just the strength that matters, it's how the sensory and motor functions integrate. If we ask a patient to exert maximum strength, they probably can do it. But if we ask them to dexterously complete a fine motor task, they have difficulty."

Continues Dr. Li, "We are currently developing a proprioceptive testing method where we focus on one digit and one joint to see if the patient can sense where the joints are. For example, we use a fake finger with different positioning and see if the patient can match that position. Our hypothesis is that patients will generate a larger error in matching the target position due to sensory deficit. Our hope is that this pinpoints the specific impairment of the sensorimotor functioning of the hand because measuring hand dexterity alone is too broad."

The Hand Research Laboratory led by Dr. Li is outfitted with cutting-edge engineering facilities. Says Dr. Li, "Carpal tunnel syndrome patients commonly experience finger stiffness and muscle tightness. Our laboratory developed a robot-assisted method to investigate finger joint stiffness. Torque-angle data were obtained from live human fingers. We examined how intrinsic muscle tightness regulates finger joint mechanics. Such objective and accurate data are valuable in detecting joint abnormality, areas where subtle changes are difficult to assess using traditional, subjective methods.

Dr. Li's work has been recognized in many quarters. Most recently, he was selected to receive the Frank E. Raymond Memorial Research Grant from the Orthopaedic Research and Education Foundation to study the functioning of the thumb. "With this grant we will be studying how relevant thumb functioning is to carpal tunnel syndrome. The sophisticated thumb motion is a hallmark of the human hand. We want to identify the motion deficit of the thumb caused by carpal tunnel syndrome. This is appealing because the median nerve is connected with some of the thumb muscles, thus some of the movement would be preferentially impaired with median neuropathy. We are putting reflective markers on patients' thumbs and are using a motion analysis system to collect their motion and then calculate the three-dimensional joint kinematics from patients. From a basic science perspective, we also want to understand how each individual muscle contributes to the observed thumb motion using cadaver hands. Up to now, we have had rather gross knowledge about the kinesiological functioning of the thumb muscles, which has been largely based on dissection and observation. With our methods, we can study the detailed behavior of each individual muscle in generating movements in multiple directions across multiple joints. For example, we have found that the extensor pollicis longus alone generated as many as six movements. We also determined, in strong contrast to the functional anatomy, that the abductor pollicis longus produced extension and supination at the carpometacarpal joints, with no abduction. Going forward we will advance our basic science as well as clinical practice."

Now back to that transverse carpal ligament. "This is an exciting project for me," says Dr. Li. "I believe that the pathomechanics of the carpal tunnel are a critical component of carpal tunnel syndrome. The standard surgical treatment is to cut the transverse carpal ligament, thus releasing the pressure in the carpal tunnel. We speculate that the thickness of the transverse carpal ligament may contribute to the elevated pressure. Repetitive use of the hand may promote hypertrophy of this ligament. We really need to understand the transverse carpal ligament."

And because of his diligence, Dr. Li will now be able to put more hard data behind his hypotheses. Dr. Li: "I was just awarded an NIH grant to study the biomechanical properties of the transverse carpal ligament. We are going to look at the mechanical and material properties of the transverse carpal ligament and generate a computer model so we can predict and simulate different conditions, including a variety of pressures, a change in the material properties of the ligament, etc. This

is an important ligament about which little is known. In contrast with the ACL [anterior cruciate ligament] in the knee, which has been extensively and meticulously researched, the TCL [transverse carpal ligament] in the hand is the best kept secret. The reason may be that the surgical procedure has been easy and well tolerated. There are side effects, however. The transverse carpal ligament is an anatomical structure with important biomechanical and physiological functions. As such, it is better to preserve it than cut it if alternatives are made available. At this point I must mention Lee Berger, M.D., for his invention of balloon carpal tunnel plasty. He developed a procedure where instead of cutting the transverse carpal ligament, you stretch it to relieve the pressure. This concept is very appealing, and I believe in its potential impact on health care. Here at the Hand Research Laboratory we are asking questions such as, 'Can we manipulate this ligament so that it's not being cut? Can we manipulate it biomechanically and biologically to preserve the integrity of the carpal tunnel and improve symptoms?' In order to do that we first have to undertake basic science research on the ligament."

In the end, the circle comes back to the patient in pain. States Dr. Li, "My goal would be to understand the mechanisms and develop early diagnostic methods and assessment tools to quantify the stages of degeneration. If we completely understand the pathogenesis, we could design strategies to prevent it. If we can help patients with alternative, minimally-invasive treatment methods, that would be an extremely rewarding part of my work."

Orthopedics This Week is published 40 times a year by RRY Publications LLC, a subsidiary of Robin Young Consulting Group.
116 Ivywood Lane, Wayne,PA 19087 877-817-6450 www.ryortho.com
Reprinted with permission of RRY Publications LLC