

AMERICAN SOCIETY FOR PERIPHERAL NERVE

Newsletter



Fall 2010

President's Message



It has been an honor to serve as the President of the American Society for Peripheral Nerve over the past 10 months. I appreciate the opportunity to help guide our society as it continues to grow and transform into a vibrant and active subspecialty society that promotes peripheral nerve surgery through scholarly academic pursuits, creativity, and clinical excellence. It has been exciting to watch the society mature and develop into a robust society with an extremely bright future.

During the past year, I have focused my energy on enhancing our relationship with AAHS and ASRM; so that we can provide a cohesive, integrated, and wonderful educational experience for everyone attending the ASPAN meeting this year from January 14-16, 2010 at the Ritz-Carlton in beautiful Cancun, Mexico.

Through the combined efforts of David Brown, MD, ASPAN Program Chair, and Joan Lipa, MD, ASRM Program Chair, and Jesse Jupiter, AAHS Program Chair, we have developed a highly integrated program with a series of combined panels, scientific sessions, instructional courses and scientific papers: ASPAN/AAHS on January 14; ASPAN/AAHS/ASRM on January 15; and ASPAN/ASRM on January 16, 2010.

We are delighted to be able to announce that this year's invited speaker for the Combined AAHS/ASPAN/ASRM meeting will be Bob Woodruff; a person known to all of us, who can provide us with a first-hand account of the benefits of reconstructive surgery.

With the enhanced integration of our scientific program with the programs of AAHS and ASRM; we will be able to highlight the best basic science and clinical peripheral nerve research from all three societies, within our own ASPAN scientific program, without competing sessions or scientific overlap with the other societies. AAHS and ASRM will also benefit by experiencing the fine research performed by our ASPAN members, which may ultimately entice them to become more involved in ASPAN in the future.

We are very pleased that our partnerships with ASRM and AAHS have been so productive for many years and have been further refined over the past year. I can speak for all of us at ASPAN when I say that our relationship with the members and leadership of the American Society of Plastic Surgeons (ASPS) and Plastic Surgery Education Foundation (PSEF) have also never been stronger.

This can only help to improve the quality and recognition of ASPAN in the future. Although we are a relatively small group, we have made a very big impact in the field of neuroscience and peripheral nerve regeneration. I am very excited about the new relationships we have developed and the old relationships which we have enhanced, to be able to provide the optimal educational and research experiences for our membership.

I look forward to an outstanding meeting in Cancun and hope to see all of you there.

Paul S. Cederna, MD FACS
ASPAN President

From the Editor's Desk

The air is crisp; the trees are gorgeous with hues of reds, oranges, yellows and greens and the beautiful fall is upon us. Welcome to the fall edition of the ASPN newsletter. I echo our president's emphasis that in spite of being a relatively small society we have had a palpable impact on neuroscience and peripheral nerve surgery.

The Plastic Surgery Educational Foundation (PSEF) is going through a huge concentrated effort to establish a website based information source that serves all the different aspects of plastic surgery. We are pleased that there is a special section for peripheral nerve surgery. Members of our society will be able to tap into that website.

In this edition you will find scientific articles that represent the wide spectrum of our society's activities in peripheral nerve surgery and research. This wide spectrum is represented by Dr. Bob Russell's article about the use of perforator flap for treatment of recurrent carpal tunnel syndrome to Dr. Wei's article about the influence of conductive polymers on neuroma formation.

I would like to extend a special thank you to the Newsletter committee members and to all of you who have contributed to the newsletter. Your contributions help to make our newsletter relevant and informative.

I am looking forward to seeing all of you in *Beautiful Cancun* where a stimulating and provocative meeting is waiting along with the beautiful sunshine and the spectacular beaches.

Hope to see you all in Beautiful Cancun.

Nash Naam, MD FACS

Editor

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Invitation to the ASPN 2011 Meeting

Cancún, Mexico



Ahhh....Cancún and the Ritz Carlton, what a fantastic combination for the annual meeting of the American Society of Peripheral Nerve!

We have a fantastic meeting planned and are glad to have you join us. The program will span three days, and be the most fully integrated meeting along with AAHS and ASRM groups ever. On Friday we will begin our meeting and join together with AAHS for combined panel sessions and talks. Saturday will showcase the coming together of all three societies for shared interests that will be of interest to all.

Our combined day meeting highlight will be a talk from acclaimed network news anchor Bob Woodruff. Bob was critically injured when his embedded unit was struck by an IED in Iraq. Bob and his wife Lee have written an inspirational book about their experiences with his injuries and his remarkable recovery. It is only fitting that he will be able to share some of his thoughts with those people who dedicate their lives to similar reconstruction.

Sunday will conclude the meeting with more panels and talks exclusive to ASPN, but will also feature more integration of overlapping interests with our other sister organization, ASRM. I would like to sincerely thank ASPN President, Paul Cederna, and Jesse Jupiter and Joan Lipa, program directors for AAHS and ASRM respectively, as well as the other leadership of all three organizations for their assistance and support in making this the most integrated annual meeting in our history.

David L. Brown, MD
Program Chair





The Ritz Carlton Hotel - Beautiful!!!



Air balloons over the ruins



We will have fun anywhere

Registration for the ASPN 2011 Annual Meeting Is Now Available Online At: www.cancun-meeting.com

Hotel Information

In an effort to accommodate the diverse needs of our attendees, AAHS, ASPN and ASRM have selected two of Cancún's finest resorts to play host to the 2011 meetings. The resorts are adjacent, and although they are only separated by a few minutes walk, a shuttle will be provided during peak meeting and meal times. All meetings and events will take place at The Ritz-Carlton. Register for rooms at our specially discounted rate two convenient ways: online at www.cancun-meeting.com; or by calling the resorts directly using the phone number listed on the housing form located on the website.

The Ritz-Carlton Cancún

In traditional Ritz-Carlton fashion, this resort experience enlivens the senses, instills well-being and fulfills every request with the word yes. Situated on the largest resort beach in Cancún, all rooms and suites overlook the Caribbean Sea. Service at it's finest; refined ambiance guaranteed. For more resort information visit www.ritzcarlton.com/en/Properties/Cancun.

The Le Meridien Cancún Resort & Spa

Overlooking white-sand beaches and the turquoise waters of the Caribbean Sea, Starwood's Le Meridien Resort offers the perfect blend of natural beauty, luxury, sophistication and Mayan mystique. The resort's luxurious residential-style guest rooms feature views of the Caribbean Sea or Laguna Nichupté. Amenity rich, this resort is one of the shining stars of Cancún. For more resort information, visit www.starwoodhotels.com/lemeridien/property/overview/index.html?propertyID=1877

Rates do not include tax. There will be no resort fees. The cutoff date for special room rates is 5:00 pm Central Time on December 13, 2010 or until the group block is full, whichever occurs first. We encourage early reservations to ensure room and rate availability.

Destination Information

Customs and Travel Documents

Travel into Mexico from the US and other countries require a valid passport or tourist card. Visit: http://travel.state.gov/passport/passport_1738.html for complete instructions and U.S. travel rules.

Currency

The U.S. dollar and Mexican Pesos are commonly used in Mexico. Major U.S., Canadian, and European banks have branches in Cancún, and the host hotels have ATM machines that are linked to major worldwide banking networks. All major credit cards (Discover Card excluded) are widely accepted. Check up-to-date currency exchange rates at www.xe.com/ucc.

Legal Drinking Age

The legal drinking age is 18 in Cancún. Please be aware that if you are traveling with children 18 and older, they are legally permitted to consume alcohol.

Electricity

The standard is 110 volts. Hotels usually offer voltage converters for 220 volt devices. Some sockets do not accept polarized or three-prong plugs.

Time Zone

Cancún operates on the Central Time Zone.

Phone and Internet Communications

Our host hotels offer high speed internet in guest rooms. Our exhibits area will also include limited, complimentary internet access during business hours. Some U.S. cell phone carriers provide coverage in Cancún. Before you leave home, be sure to check with your provider for any applicable roaming fees or set up requirements. Prepaid calling cards are also popular for keeping in touch with home. For dialing instructions to and from Cancún, visit www.howtocallabroad.com.

Security

For the convenience and security of our attendees, AAHS, ASPN and ASRM have arranged for private shuttles to and from the Cancún International Airport. We are also offering private optional tours. Private is defined as designated only for the AAHS, ASPN and ASRM attendees. Both of these conveniences are available to the attendees. We would encourage all attendees to take advantage of these services.

Transportation

Cancún Airport International (CUN)

One of the busiest airports in the Caribbean, Cancún Airport International is located approximately 15 minutes from our host resorts. Served by all major airlines, many of which offer non-stop, low cost flights, getting to Cancún is a breeze. Book early and save by using your favorite travel websites. Check out the newly renovated Cancún airport at www.cancun-airport.com.

Private Transportation

For your convenience, AAHS, ASPN and ASRM made special arrangements for attendees who are staying at the host hotels, to be greeted at the Cancún airport. Advance reservations are required. If you reserve a private SUV or van, or, you choose to ride-share with other group members, our greeters will meet you outside the terminal with an AAHS-ASPN-ASRM sign and will assist you to the host hotels only: The Ritz-Carlton or Le Meridien. This service must be arranged and paid for in advance to guarantee services. One way fare in a private vehicle ranges from \$99 to \$150; shared group shuttle fare is \$24 + 15% gratuity per person one way. On your departure day, our travel partner will provide private cars, or shared shuttles from the host hotels to the airport, based on your reservation. Please visit <https://ividmc.com/tours/aahs-aspn-asrm> to make your reservations and learn more about these services. If you are staying at an alternate hotel, taxis and public shuttles are safe and readily available at the airport.

Shuttle

Shuttle fare is \$24+15% gratuity per person one way. On your departure day, our travel partner will provide private cars, or shared shuttles to the airport based on your request. Please visit <https://ividmc.com/tours/aahs-aspn-asrm> to make your reservations.

Taxis

Taxi service is also readily available everywhere. Expect to pay \$65 plus tip airport to resort, and \$35 plus tip resort to airport. All transportation options are considered safe and reliable.

Buses

Buses run from Cancún City to the hotel zone between 6:00 am and midnight. Each segment costs about seven pesos (a little under a dollar, must use Mexican coins.)

Rental Cars

Many well known car rental agencies operate at the airport, along with a highly regulated Cancún-bound shared ride shuttle. Visit the airport's website for information on rates and schedules. Rental cars are available at the resorts, and at locations minutes from the resorts. Email the resorts' concierge for assistance by visiting the resort websites. In Cancún, drivers sit in the left seat position, and seatbelts are required. Platinum, an exotic car rental company, operates a desk at the Ritz-Carlton. Make reservations at www.platinumcarrental.com.

FUTURE ANNUAL ASPN MEETINGS

2012 Annual Meeting

January 14-15
Red Rock Casino Resort
& Spa
Las Vegas, Nevada

2013 Annual Meeting

January 11-13
Naples Grande Resort
& Club
Naples, Florida

2014 Annual Meeting

January 10-12
Grand Hyatt Kauai
Resort & Spa
Kauai, Hawaii

Annual 2011 Meeting-at-a-Glance

Friday, January 14

7-8 am	Instructional Courses (6 options - see p. 9-10)
	Instructional Courses (3 options - see p. 12)
8-10:15 am	Welcome and Panel: Innovative Hand Surgery - An International Perspective
	Welcome and Panel: Nerve Transfers
	Debates (2)
	Lecture: Nerve Surgery - An Historical Perspective
	Presidential Panel: Back to the Future - Current Advances and the Future of Nerve Surgery
10:30-11:45 am	Scientific Paper Sessions A & B
	Scientific Paper Session A
	Joint Concurrent AAHS/ASPN Panels: Assessment and Management of the Mangled Hand
	Failed Nerve Decompression - Now What?
11:45 am - 1:15 pm	Danyo Lecture
	Scientific Paper Session B and Lunch
	Annual Business Meeting - AAHS Members Only
1:30-5:50 pm	Comprehensive Hand Review Course
5-6 pm	Special Session: Scientific Posters
7-10 pm	Awards Dinner Dance

Saturday, January 15

Combined Day

7-8 am	Instructional Courses (6 options - see p. 14)
8:15-9:30 am	Presidents' Welcome and Panel: Robotic Surgery
10-11 am	Joint Presidential Keynote Lecture - Bob Woodruff
11 am - 12 pm	Joint Outstanding Papers
12-1 pm	Scientific Paper Session C and Lunch
12-5 pm	Master Series - Tricks, Tips, and Pearls: Insights from the Masters
5-6 pm	Special Session: Scientific Posters
6:30-6:30 pm	ASPN/ASRM Welcome Reception

Sunday, January 16

7-8:15 am	Instructional Courses (2 options - see p. 13)
8:15-9:30 am	Panel: Treatment of Migraine Headaches via Nerve Interventions
	President's Invited Lecturer - Roger Khouri, MD
	William G. Shaw Memorial
9:45-10:45 am	Scientific Paper Session D
	Concurrent Scientific Paper Sessions
10:45-11:45 am	ASPN/ASRM Panel: Facial Paralysis
11:45 am - 1:30 pm	Scientific Paper Session E and Lunch
	Instructional Courses (4 options - see p. 17)
	Annual Business Meeting - ASPN Members Only
1:15-2:45 pm	ASRT Update
4-5 pm	Poster & Exhibits Reception
5-7 pm	Best Case/Best Save

2011 Annual Meeting Program

Friday, January 14

- 6:30 – 7 am Continental Breakfast
- 7 – 8 am Instructional Courses
- 301 Evaluation and Treatment of Disproportionate Pain and Disability
Instructors: David Ring, MD
- 302 Obstetrical Brachial Plexus Palsy and Nerve Transfers
Chair: Thomas Tung, MD
Instructors: Gregory Borschel, MD; Scott Kozin, MD
- 303 Pediatric Peripheral Nerve Considerations
Co-Instructors: Howard Clarke, MD, PhD; Lynda Yang, MD, PhD
- 8:15 – 8:25 am President and Program Chair Welcome
Paul Cederna, MD, President
David Brown, MD, Program Chair
- 8:25 – 9:10 am Panel: Nerve Transfers
Moderator: Thomas Tung, MD
Panelists: Robert Spinner, MD; Lynda Yang, MD, PhD; Christine Novak, PT MS PhD
- 9:10 – 9:30 am Lecture: Nerve Surgery – An Historical Perspective
Invited Lecturer: David Kline, MD
- 9:30 – 10:15 am Presidential Panel: Back to the Future - Current Advances and the Future of Nerve Surgery
Moderator: Paul Cederna, MD, ASPN President
Panelists: Howard Clarke, MD, PhD; William Kuzon, MD; Rajiv Midha, MD
- 10:15 – 10:30 am Coffee Break with Exhibitors
- 10:30 – 11 am Scientific Paper Session A
- 11 – 11:45 am Joint Concurrent AAHS/ASPN Panel: Failed Nerve Decompression – Now What?
Moderator: Allen Van Beek, MD
Panelists: Allan Belzberg, MD; Tsu-Min Tsai, MD
- Joint Concurrent AAHS/ASPN Panel: Assessment and Management of the Mangled Hand
Moderator: Jesse Jupiter, MD
Panelists: Neil Ford Jones, MD; Rajan Gupta, MD; L. Scott Levin, MD; William Pederson, MD;
and Luis Schecker, MD
- 11:45 am – 1:15 pm Scientific Paper Session B and Lunch
- 5 – 6 pm Special Session: Scientific Posters

Sunday, January 16

6:30 – 8 am	Breakfast with Exhibitors
7 – 8 am	Instructional Courses
	304 Lower Extremity Nerve Decompression in the Patient with Diabetes Chair: A. Lee Dellon, MD Instructors: Ivica Ducic, MD, PhD; Maria Siemionow, MD PhD DSc
	305 Reinnervating Muscle: From the Lab to the Clinic Chair: Tessa Gordon, PhD Instructors: K. Ming Chan, MD; Rajiv Midha, MD
8:15 – 9:15 am	Panel: Treatment of Migraine Headaches via Nerve Interventions Moderator: Bahman Guyuron, MD Panelists: Ivica Ducic, MD, PhD; A. Lee Dellon, MD
9:15 – 9:45 am	Coffee Break with Exhibitors
9:45 – 10:45 am	Scientific Paper Session D
10:45 – 11:45 am	Joint ASPN/ASRM Panel: Facial Paralysis Moderator: Michael Klebuc, MD Panelists: Chris Coombs, MD; Eyal Gur, MD; William Kuzon, MD; Ronald Zuker, MD
11:45 – 12:45 pm	Scientific Paper Session E and Lunch
12:45 – 1:30 pm	Annual Business Meeting (ASPN Members Only)

**The ASPN Council and 2011 Annual Meeting Program Committee
would like to thank the growing list of exhibitors and sponsors
of our meeting**

SPONSORS

AAHS Friday Break: Medartis
ASPN & ASRM Welcome Reception: ASSI
Internet Cafe: Auxilium
Buncke Lecture: CPMC
ASRM Best Case/Best Save: Synovis

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Members in the NEWS

Millesi-Award for Nerve Surgery Pioneer, Dr. David Chiu



Vienna, 3/22/2010 - Dr. David Chiu, one of the world's most influential pioneers in nerve surgery, was accorded the renown Millesi Award today for his life's work. The accolade was presented during the 3rd symposium on peripheral nerve surgery at Vienna's Millesi Center for Peripheral Nerve Surgery.

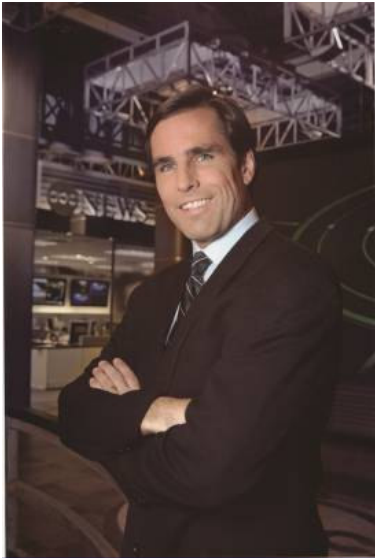
Dr. Chiu, who teaches at the New York University Medical College, achieved prominence for his work, among other things, in the development of so-called "venous implants," a simple, cost effective and easily manageable method of bridging injury-related severed nerve conduits by inserting a piece of vein and thereby providing the needed support for regeneration.

His latest pioneering accomplishment is his contribution to the discovery that spinal cord nerve pathways can regenerate under certain circumstances, something hitherto considered impossible. This finding could open up completely new treatment perspectives in the future.



Combined Day Invited Speaker

Bob Woodruff



Bob Woodruff joined ABC News in 1996 and has covered major stories throughout the country and around the world for the network. He was named co-anchor of ABC's *World News Tonight* in December 2005. On January 29, 2006, while reporting on U.S. and Iraqi security forces, Woodruff was seriously injured by a roadside bomb that struck his vehicle near Taji, Iraq. Woodruff is back at work reporting for ABC News shows on a variety of international and national stories with his "Bob Woodruff Reports" unit. He has continued to cover stories that focus attention on the needs of veterans from the Iraq and Afghanistan wars. He is also the anchor of a new weekly news program "Focus Earth with Bob Woodruff" which runs on the new Discovery Channel, Planet Green.

In February 2007, Woodruff and his wife Lee released *In an Instant: A Family's Journey of Love, Courage, and Healing*, their personal memoir about Woodruff's recovery after his attack in Iraq and the medical and family support that helped him heal.

In April 2008, Woodruff won a Peabody Award for *Wounds of War - The Long Road Home for Our Nations Veterans*, a series of reports that aired on ABC. He is also the recipient of the Daniel Pearl Award for Courage and Integrity in Journalism. He has received numerous awards and citations from organizations around the country for his work on behalf of the wounded veterans.

Previously the anchor of the weekend edition of *World News Tonight* and one of ABC News' top correspondents, Woodruff has covered major stories both in the United States and overseas. His reports from New Orleans in the aftermath of Hurricane Katrina helped focus the nation's attention on the building tragedy there. He was ABC's lead correspondent on the Asian Tsunami, reporting from Banda Aceh, Indonesia and Sri Lanka. Woodruff has covered the entire so-called "axis of evil," the nuclear showdown in Iran, and in June 2005 he got unprecedented access to the secretive country of North Korea. In the last presidential election he reported on the campaign of Senator John Edwards. He has also reported extensively on the continuing unrest in Iraq from Baghdad, Najaf, Nassariya and Basra. During the initial invasion, Woodruff reported from the front lines as an embedded journalist with the First Marine Division, 1st Light Armored Reconnaissance Battalion.

Before moving to New York in 2002, Woodruff worked out of ABC News' London Bureau. After the September 11 attacks, he was among the first Western reporters into Pakistan and was one of ABC's lead foreign correspondents during the war in Afghanistan, reporting from Kabul and Kandahar on the fall of the Taliban. His overseas reporting of the fallout from September 11 was part of ABC News' coverage recognized with the Alfred I. duPont Award and the George Foster Peabody Award, the two highest honors in broadcast journalism. He was also a part of the ABC News team recognized with an Alfred I. duPont award for live coverage of the death of Pope John Paul II and the election of Pope Benedict XVI.

Before becoming a journalist, Woodruff was an attorney. But in 1989, while teaching law in Beijing, he was hired by CBS News to work as a translator during the Tiananmen Square uprising and a short time later he changed careers. As ABC's Justice Department correspondent in Washington in the late 1990's, Woodruff covered the office of Attorney General Janet Reno, the FBI and ATF. In 1999, he reported from Belgrade and Kosovo during the NATO bombing of Yugoslavia. Since then he has reported extensively on Europe and the Middle East.

Prior to joining ABC News, Woodruff was a reporter for KCPM-TV, the NBC affiliate in Redding, California, from 1991-92; for the CBS affiliate WTVR-TV in Richmond, Virginia from 1992-94; and for KNXV-TV, the ABC affiliate in Phoenix, Arizona from 1994-96. He joined ABC News in 1996, based in the network's Chicago Bureau. Woodruff has a law degree from the University of Michigan Law School and a BA from Colgate University. He is married and has four children.

What's New in Peripheral Nerve Surgery and Research

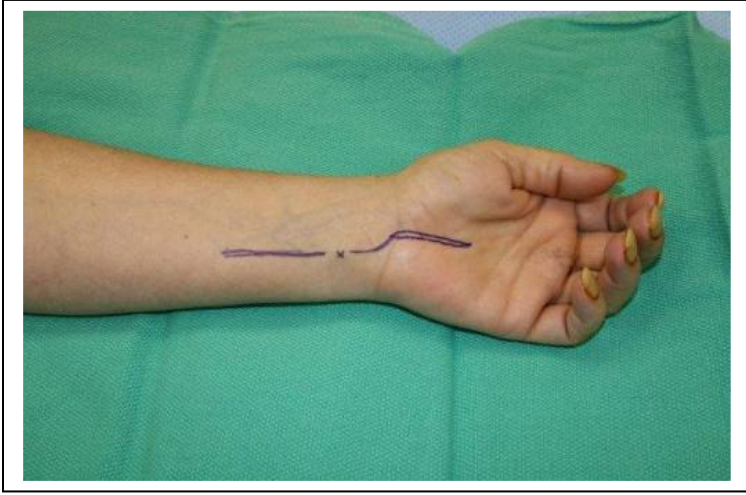
Perforator Flap Use in Recurrent Carpal Tunnel Syndrome

Robert C. Russell, MD

Southern Illinois University – Springfield, Illinois

Carpal tunnel syndrome is the most frequently treated surgical condition in America estimated at 260,000 cases per year. Most patients do well following surgical release of the median nerve without recurrent symptoms. Occasionally, however, a small percentage of patients have persistent or recurrent symptoms after surgery. The etiology of recurrent symptoms has been attributed to persistent transverse carpal ligament fibers, a superficial position of the median nerve which is actually out of the carpal tunnel and/or dense scar surrounding the median nerve. The nerve in these patients may be easily irritated with hand use and/or be relatively ischemic in its course across the wrist into the hand. Previous authors have described the use of palmaris brevis turnover flaps or synovial flaps after secondary or tertiary carpal tunnel release in an attempt to surround the nerve with vascularized soft tissue or as a method to maintain the nerve in a deep position within the carpal canal. Many patients, however, lack adequate tissue in the zone of surgical trauma which itself is injured, to provide adequate soft tissue coverage after one or more previous surgeries and are prone to form more scar.

For several years I have used a subcutaneous tissue ulnar artery perforator flap from the distal forearm to surround the median nerve in the carpal canal in these more difficult cases. The normal carpal tunnel incision is extended proximally from the wrist crease toward the ulnar side of the wrist and then vertically along the radial side of the flexor carpi ulnaris tendon. The skin edges are elevated at a subdermal level for a total width of 3 to 4 cm. The subcutaneous tissue is then incised to the underlying deep muscle fascia and a subfascial plane is created from the tissue overlying the forearm muscles toward the ulnar artery. This flap is elevated from proximal to distal identifying small perforating branches off the ulnar artery which arise approximately two cm proximal to the pisiform. This flap is then rotated 180 degrees distally to cover the median nerve in the carpal tunnel providing vascularized fat and fascia. The flap protects and cushions the nerve, and maintains it in a deep position within the carpal canal. The donor site skin flaps over the volar forearm are relatively ischemic following this procedure and occasionally are slow to heal. None of our patients with this flap have required a secondary procedure or another carpal tunnel release. A subcutaneous ulnar artery perforator flap is a simple effective way to provide "virgin" vascularized soft tissue to cover the median nerve in the wrist in select patients with recurrent carpal tunnel symptoms after one or more previous surgical releases.



The incision



The Flap after being elevated and applied in the carpal tunnel



Post operative scar



Feasibility of Conductive Polymer for Peripheral Nerve Interfaces

Ziya Baghmanli, MD¹; Melanie G Urbanek, PhD¹; Benjamin Wei, MD¹; Bong Sup Shim, PhD²; David C Martin, PhD²; Paul S Cederna, MD¹

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²Department of Materials Science, University of Delaware, Newark, DE

Introduction:

Autonomous prosthetic control is desired by patients with extremity amputation. Amputees experience loss of independence along with decreased limb functionality. Recent developments now allow personal control of prosthetics by communicating through either a central or peripheral nervous system (CNS or PNS) – machine interface. Scalp surface electrodes (Birbaumer 2006), brain cortical electrodes (Leuthardt, Schalk et al. 2003), brain implantable electrodes (Serruya, Hatsopoulos et al. 2002), and nerve cuff electrode (Schiefer, Triolo et al. 2008; Brill, Polasek et al. 2009), are used to control devices; however, interface reliability over time, lack of algorithm efficiency, and required complex learning are pitfalls of these approaches. (Lebedev and Nicolelis 2006)

Because all the neural information (action potentials) needed to functionalize prostheses are located in the peripheral nerve stump of an amputee, we favor a local peripheral nerve interface (PNI). The peripheral nerve signals are already filtered and the nerves are easily surgically accessible for implanting a recording device. However implanted recording devices face the same problems as their CNS counterparts; decreased signal fidelity due to scarring and lack of reliability over time. Any proposed interface between peripheral nerve and prosthetic wire should address these problems, as well as, provide high fidelity signal translation from ionic (peripheral nerve action potential) to electronic (wire) transmission.

Past research shows that the polymer poly (3,4-ethylenedioxythiophene) (PEDOT) decreases impedance and increases conductivity for substrates upon which it is polymerized. (Egeland 2010; Urbanek MG March, 2010) PEDOT can be polymerized around neural cells (Richardson-Burns, Hendricks et al. 2007) and reveals no deleterious effect on neural and muscle cell cultures. (Urbanek MG 2008; Egeland 2010) In a peripheral nerve study of acute gap repair, acellular material polymerized with PEDOT allowed signal transmission across a nerve gap up to 20 mm in length. (Urbanek MG March, 2010) These results establish reasons for including PEDOT in our experimental peripheral nerve interface (PNI), but we first need to know how divided peripheral nerve behaves after long term exposure to PEDOT. Therefore, we have evaluated peripheral nerve regeneration in the presence of PEDOT.

Materials & Methods: PEDOT was polymerized on decellular nerve (AxoGen™, Alachua, FL) using 3,4-ethylenedioxythiophene monomer (Baytron M, H. C. Strack MA) and anhydrous FeCl₃ (Acros Organics, Geel, Belgium) (Peramo, Urbanek et al. 2008) A hindlimb peroneal nerve model was used with F344 rats (Charles River, Wilmington, MA). All experiments were in compliance with University of Michigan UCUC guidelines. After exposure of the common peroneal nerve through a lateral thigh approach, a 15 mm gap was created in the nerve. Experimental groups were defined based on gap reconstructive procedure type. The groups were: 1) Sham, (no nerve gap created); 2) Autograft (gap was reconstructed with use of fresh autograft); 3) Decellular nerve (DN) (gap was reconstructed with use of DN); 4) PEDOT polymerized decellular nerve (PEDOT)(gap was reconstructed with use of PEDOT and DN); 5) No reconstruction (gap not reconstructed). Thin acellular small intestinal submucosal tissue piece was placed around all nerve reconstructions. Animals were allowed to recover postoperatively for 90 days at ULAM facilities of the University of Michigan. At the end of follow-up period, nerve regeneration was assessed with nerve conduction studies and muscle contractile property measurements. To test nerve conduction, incremental and maximal electrical stimulations were applied directly to the peroneal

nerve, proximal to the constructs via hook electrode. (Harvard apparatus, Holliston, MA) Generated action potentials were recorded from *the extensor digitorum longus muscle*. To define muscle contractile properties, supramaximal electrical stimuli were applied to the regenerated peroneal nerve and simultaneously generated maximum isometric tetanic forces were measured. Histomorphometric analysis was then performed using the previously described nerve histology grading system (Murji, Redett et al. 2008) (Table 1)

Results: All groups except the Gap group revealed functional results interpreted as successful regeneration of peripheral nerves. During nerve conduction studies, velocity in the PEDOT group was significantly ($p<0.05$) higher than for the DN group. (Fig 1) Amplitude of compound action potentials in the PEDOT group was comparable with the positive control, Sham group (Fig 2) Maximal isometric tetanic force for the PEDOT group was significantly lower than for the sham and autograft groups, however there was no significant difference between decellular nerve and PEDOT groups.(Fig 3). Histologic evaluation of the nerves revealed gradually increasing total score, from low to high, sham<autograft<decellular nerve<PEDOT<gap, for which low scores indicated better peripheral nerve histological outcomes. (Fig 4)

Conclusion: Our results show that a conductive polymer, PEDOT can be incorporated into biological materials, in our case decellularized nerve. The construct supports successful peripheral nerve regeneration. PEDOT-decellular nerve is also maintained as a stable construct over time without inducing a significant inflammatory reaction. High conduction velocity for the PEDOT group after 90 days is consistent with results obtained in an acute nerve injury setting. (Egeland, Urbanek et al. 2009; Urbanek MG March, 2010) There are discrepancies in results for measurements of muscle force (PEDOT group recovered poorly) and nerve histology ratings (PEDOT group rated poor) with those for nerve conduction studies (PEDOT group did well). These results may be explained by axon growth being mechanically obstructed due to the deposition of PEDOT (data not shown) inside the decellular nerve conduits, however this needs to be investigated in further studies.

Acknowledgements: The views expressed in this work are those of the authors and do not necessarily reflect official Army policy. This work was supported in part by the Department of Defense Multidisciplinary University Research Initiative (MURI) program administered by the Army Research Office under grant W911NF0610218 and Plastic Surgery Educational Foundation under Pilot Research Grant (#172613)

Table 1: Modified Peripheral Nerve Grading System (Murji, Redett et al. 2008)

<u>Epineurium</u>	<u>Endoneurium</u>		Definition	<u>Perineurium</u>	
Microfascicles	Free Space	Organization		Thickening	Microfascicles
None (1)	Normal (1)	Good (1)	Good (1)	None (1)	None (1)
Rare (2)	Mild increase (2)	Poor (2)	Poor (2)	Mild (2)	Rare (2)
Moderate (3)	Moderate (3)	None(3)	None (3)	Moderate (3)	Severe (3)
Severe (4)	Severe (4)			Severe (4)	
Extensive (5)					

This scale is a modified version of what is described previously (Murji, Redett et al. 2008) Scores e.g. “None-1” indicates a score of 1 as no microfascicles were seen outside the epineurium. “Extensive-5” indicates a score of 5, which reflects barely recognizable epineurium/no epineurium, so microfascicles are observed throughout all section. “Rare-2”, “Moderate-3”, “Severe-3” are graded by density of microfascicles seen at epineurium. Nerves were evaluated independently by two observers.

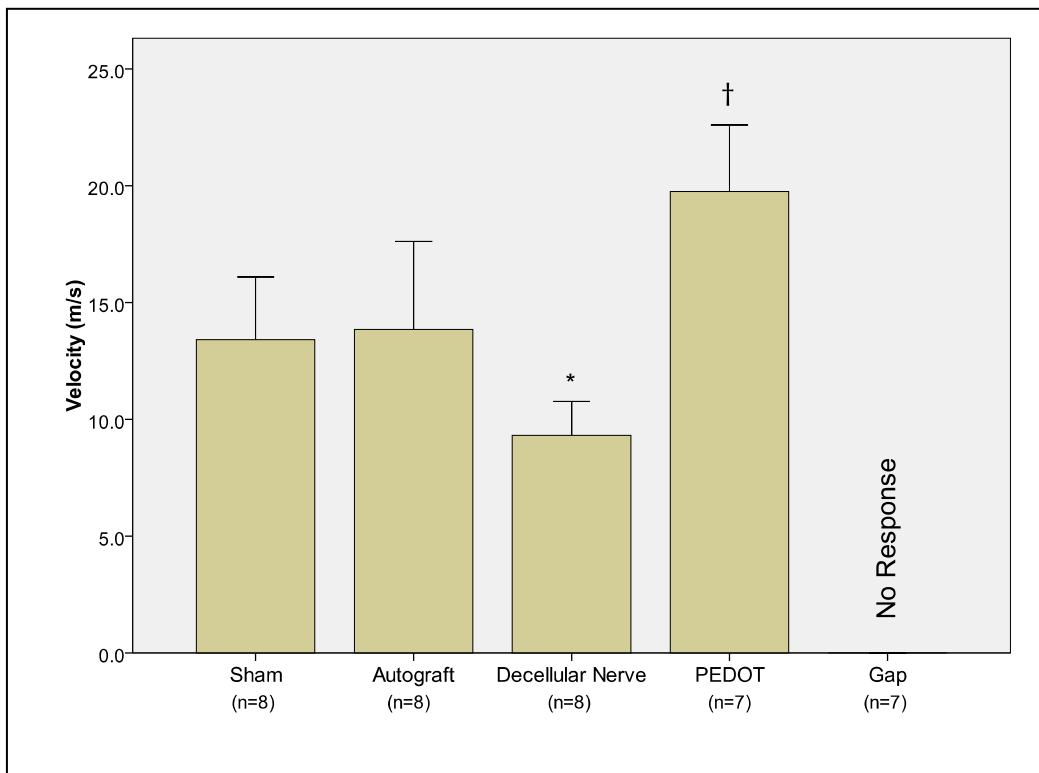


Figure 1: Conduction velocity of action potential in experimental groups. Values shown are mean±SD, $p < 0.05$, * represents significant difference when compared to Sham, † represents significant difference compared to Decellular Nerve group. Note that the PEDOT group conducts faster than the Decellular Nerve group.

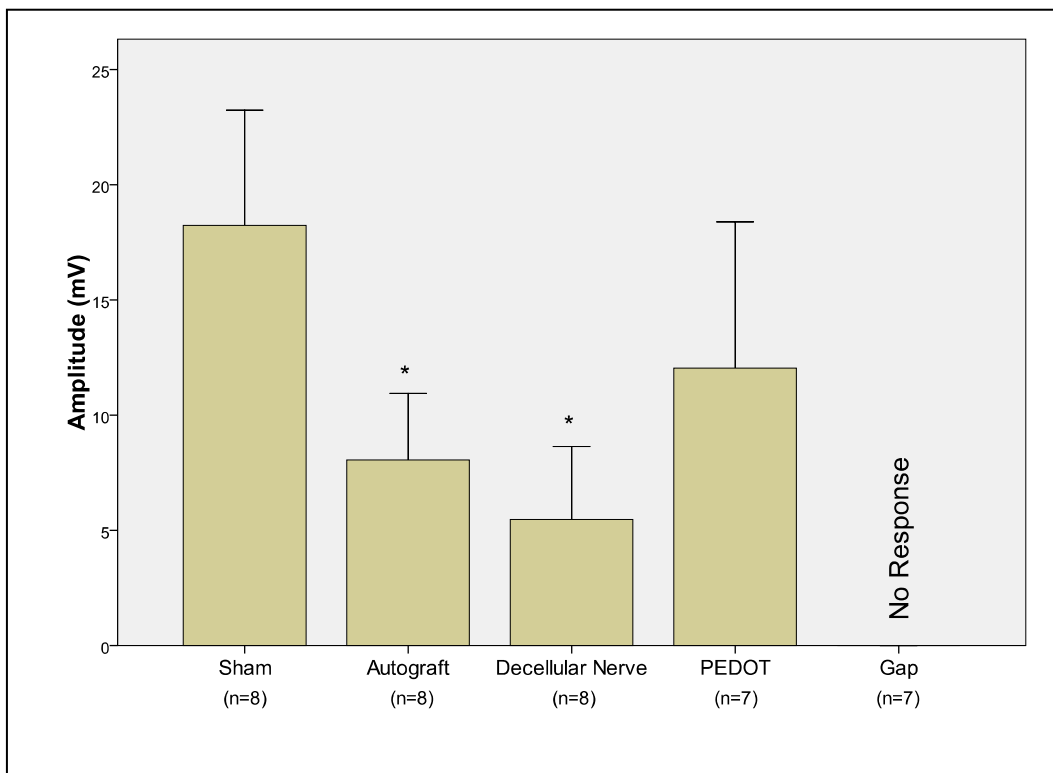


Figure 2: Amplitude of compound action potentials in experimental groups. Values are shown as mean±SD, $p < 0.05$, * represents significant difference compared to Sham. Note that there is no statistical significant difference between Sham and PEDOT groups

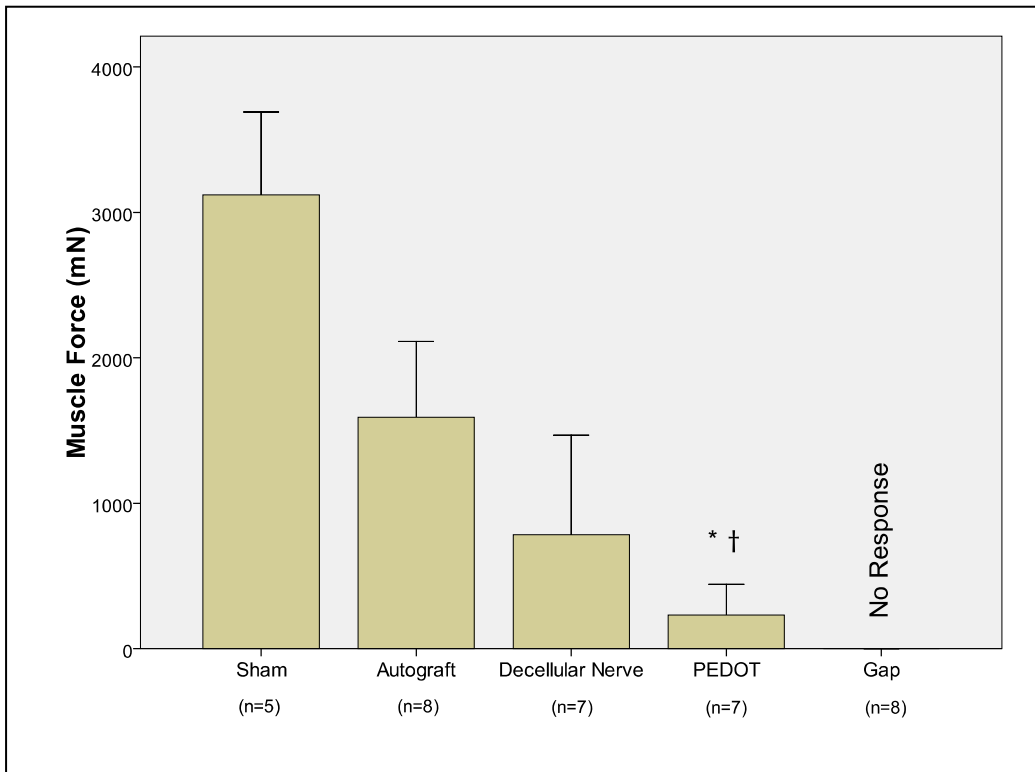


Figure 3: Muscle Force in experimental groups. Values shown are mean±SD, $p < 0.05$, * indicates different from Sham, † indicates different from Autograft. Note statistically significantly lower muscle forces in PEDOT compared to Sham and Autograft groups.

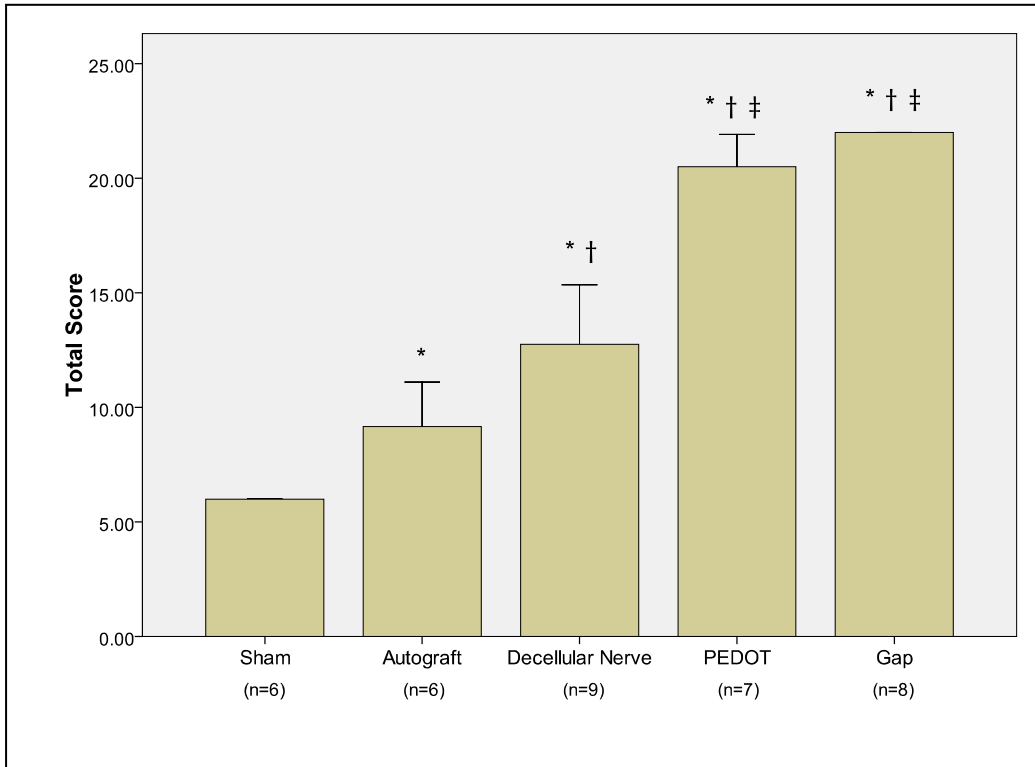


Figure 4: Summary of Peripheral Nerve Grading System scoring. Values shown are the mean±SD. $p < 0.05$, * indicates different compare to Sham, † indicates different compare to Autograft, ‡ indicates different compare to Decellular Nerve group. Note: low score represents better nerve histology.

- Birbaumer, N. (2006). "Brain-computer-interface research: Coming of age." Clinical Neurophysiology **117**(3): 479-483.
- Brill, N., K. Polasek, et al. (2009). "Nerve cuff stimulation and the effect of fascicular organization for hand grasp in nonhuman primates." Conf Proc IEEE Eng Med Biol Soc **2009**: 1557-60.
- Egeland, B., Adams, Wei B, Frost CM, Jadcherla Y, Urbanek MG, Kuzon WM, Larkin L, Cederna PS (2010). "An Organic Wire: Polymer Coatings On Acellular Nerve Scaffold - In Vitro Characterization and Biocompatibility." Plast Reconstr Surg **125**(6): 53.
- Egeland, B. M., M. Urbanek, et al. (2009). "Engineering and development of a stable, low-impedance, bioelectrical peripheral nerve interface." Journal of the American College of Surgeons **209**(3): S76-S76.
- Lebedev, M. A. and M. A. L. Nicolelis (2006). "Brain-machine interfaces: past, present and future." Trends in Neurosciences **29**(9): 536-546.
- Leuthardt, E. C., G. Schalk, et al. (2003). "Developing a brain computer interface utilizing subdural electrodes in seizure-monitored patients." Neurosurgery **53**(2): 475-476.
- Murji, A., R. J. Redett, et al. (2008). "The role of intraoperative frozen section histology in obstetrical brachial plexus reconstruction." Journal of Reconstructive Microsurgery **24**(3): 203-209.
- Peramo, A., M. G. Urbanek, et al. (2008). "In situ polymerization of a conductive polymer in acellular muscle tissue constructs." Tissue Eng Part A **14**(3): 423-32.
- Richardson-Burns, S. M., J. L. Hendricks, et al. (2007). "Polymerization of the conducting polymer poly(3,4-ethylenedioxythiophene) (PEDOT) around living neural cells." Biomaterials **28**(8): 1539-1552.
- Schiefer, M. A., R. J. Triolo, et al. (2008). "A model of selective activation of the femoral nerve with a flat interface nerve electrode for a lower extremity neuroprosthesis." Ieee Transactions on Neural Systems and Rehabilitation Engineering **16**(2): 195-204.
- Serruya, M. D., N. G. Hatsopoulos, et al. (2002). "Instant neural control of a movement signal." Nature **416**(6877): 141-142.
- Urbanek MG, B. Z., Shim BS, Schroeder K, Wei B, Langhals NB, Miriani RM, Egeland BM, Kipke DR, Martin DC, Cederna PS (March, 2010). Conduction Properties Of Decellularized Nerve Biomaterials IFMBE Proceedings.
- Urbanek MG, L. L., Wellington MS, Egeland BE, Marcelo CL, Martin DC, Kuzon, Jr WM, Cederna PS (2008). "Myoblast Compatibility With A Bio-synthetic Electrically Conductive Material." Plastic and Reconstructive Surgery **121**(6S): 1.

Influence of Conductive Polymers on Neuroma Formation

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Background

An estimated 41,000 Americans experience major upper extremity limb loss each year, a number that is only projected to rise in the coming years.¹ In response to this need, the field of prosthetics has seen advances in passive, body-powered, and myoelectric prostheses.² Modern robotics holds the potential for detailed functional replication of the human hand with sensory feedback.³ In spite of these advances, the nerve-machine interface continues to be a persistent obstacle in the development of closed-loop patient-controlled prosthetics.^{3,4}

Current generation interfaces made of silicon and conductive metal electrodes can transmit nerve impulses within weeks to months, but ultimately succumb to biofouling and signal degradation.⁵ Importantly, a significant proportion of amputees suffer from neuromas, which are both painful and a source of action potential signal interference.⁶ This is a particularly difficult problem when providing stimulation of afferent nerve fibers for sensory feedback.

One key to this puzzle may lie with the polymer poly (3,4-ethylenedioxythiophene), or PEDOT. PEDOT is a highly conductive organic compound that has been shown to carry nerve signal transmission across gap lengths as long as 20 mm.^{7,8} Importantly, its structural similarity to melanin has resulted in promising biocompatible traits, including minimal deleterious effects in neural and muscle cell culture.^{9,10}

Our group intends to use this polymer in a nerve interface known as the regenerative peripheral nerve interface (RPNI). The RPNI consists of a biologic scaffolding for structural support coated with PEDOT. Muscle tissue is layered on top of this scaffolding to provide an end target for regenerating motor and sensory axonal sprouts. The proximal stump of a divided peripheral nerve is embedded in the RPNI.

Because neuromas are a significant obstacle in the success of any neural interface, we are interested in how neuroma formation is affected by the components of our RPNI, particularly PEDOT. Our null hypothesis is that neuroma formation is unaffected by the presence of PEDOT at three and six months.

Methods

We used the F344 rat (Charles River, Wilmington, MA) for this study. All animal procedures were approved by the University of Michigan Committee on Use and Care of Animals (UCUCA) guidelines. The left peroneal nerve was transected 15 mm proximal to its entry into the lateral compartment of the lower leg. The proximal stump was coated to a scaffolding of 10mm acellularized small intestinal submucosa (SIS, Cook Surgical, Bloomington, IN, USA). PEDOT (Baytron, Newton, MA) was polymerized on these scaffolds for two of the experimental groups. The first, Dry PEDOT, was chemically deposited resulting in a firm, brittle compound.¹¹ The second, Wet PEDOT, was electrochemically deposited resulting in a soft, gel polymer.¹²

The study groups (n=8 per group) were as follows: 1) sham operation, 2) divided peroneal nerve with primary repair, 3) divided peroneal nerve without repair, 4) divided peroneal nerve with SIS, 5) divided peroneal nerve with Dry PEDOT-coated SIS, and 6) divided peroneal nerve with Wet PEDOT-coated SIS. (Figure 1).

We performed von Frey testing at 3 and 6 months to evaluate tactile sensitivity. The von Frey monofilaments (Leica Microsystems, St. Louis, MO) were applied to the operative site in a stepwise fashion as previously described to determine the amount of force required to elicit a withdrawal response from the animal.¹³ Lower von Frey thresholds reflect higher sensitivity implying more pain due to nerve injury and subsequent neuroma formation within the RPNI. von Frey data were calculated using Equation 1.¹³

$$\text{Equation 1. } 50\% \text{ g threshold} = \frac{(10^{(f+ks)})}{10000}$$

f = value (in log units) of the final von Frey hair used, k = tabular value derived from the pattern of positive / negative responses, and s = mean difference (in log units) between stimuli.

The rats were sacrificed after 6 months; this time point has been shown to allow formation of mature neuromas in rats.¹⁴ Nerve samples were then harvested and processed for nerve histology. The mean and standard deviation were determined for measured variables. Statistical significance was set at $p < 0.05$. The model was subjected to Kruskal-Wallis analysis with multiple comparisons when the model was significant.

Results

At 90 and 180 days, the Divided Nerve group was more sensitive than the Sham group (Table 1). These findings validate von Frey testing as a measurement of pain, and by inference, neuroma formation. With these results we now test the hypothesis that neuroma formation is unaffected by the presence of PEDOT at three and six months. Addition of Dry PEDOT to the SIS scaffold increased the sensitivity of the operative site when compared with the SIS scaffold alone (0.013 ± 0.017 vs. 0.22 ± 0.33 , $p < 0.05$) at 90 days. However, the Wet PEDOT group sensitivity was not increased at 90 days (power = 0.61, $\alpha = 0.1$). In addition, neither Dry nor Wet PEDOT groups were significantly different from the SIS group at 180 days.

Conclusions

By distinguishing the Divided Nerve group from the Sham group, the von Frey system quantitatively stratifies subjects with and without neuromas. When Wet PEDOT is implanted adjacent to a regenerating peripheral nerve stump, there is no significant increase in tactile sensitivity at either 90 or 180 days compared to SIS scaffolding alone. The increased sensitivity of the Dry PEDOT group found at 90 days could be attributable to the mechanical incompatibility between the stiffer polymer and the soft nerve. The partial resolution of this sensitivity at 180 days may reflect desensitization of the rat over time. These data suggest that Wet PEDOT has minimal effect on neuroma formation in both the acute and chronic phases.

LITERATURE CITED

1. Ziegler-Graham, K., et al., *Estimating the prevalence of limb loss in the United States: 2005 to 2050*. Arch Phys Med Rehabil, 2008. **89**(3): p. 422-9.
2. Biddiss, E. and T. Chau, *Upper limb prosthesis use and abandonment: a survey of the last 25 years*. Prosthetics and orthotics international, 2007. **31**(3): p. 236-57.
3. Hijjawi, J.B., et al., *Improved myoelectric prosthesis control accomplished using multiple nerve transfers*. Plast Reconstr Surg, 2006. **118**(7): p. 1573-8.
4. Lamb, D.W., *State of the art in upper-limb prosthetics*. J Hand Ther, 1993. **6**(1): p. 1-8.
5. Biran, R., D. Martin, and P. Tresco, *Neuronal cell loss accompanies the brain tissue response to chronically implanted silicon microelectrode arrays*. Experimental Neurology, 2005. **195**(1): p. 115-126.
6. Soroush, M., et al., *Neuroma in bilateral upper limb amputation*. Orthopedics, 2008. **31**(12).

7. Egeland B, U.M., Richardson-Burns S, Peramo A, Martin DC, Kuzon WM, Cederna PS., *In Vivo Electrophysiologic Properties of Poly 3,4-ethylenedioxythiophene (PEDOT) in a Biosynthetic Nerve Interface*. *Plastic and Reconstructive Surgery*, 2008. **122**(4S).
8. Urbanchek MG, S.B., Baghmanli Z, Wei B, Schroeder K, Langhals NB, Miriani RM, Egeland BM, Kipke DR, Martin DC. Cederna PS., *Conduction Properties of Decellularized Nerve Biomaterials*. IFMBE Proceedings,, Accepted March 2010.
9. Egeland, B., Adams, Wei B, Frost CM, Jadcherla Y, Urbanchek MG, Kuzon WM, Larkin L, Cederna PS *An Organic Wire: Polymer Coatings On Acellular Nerve Scaffold - In Vitro Characterization and Biocompatibility*. *Plastic & Reconstructive Surgery*, 2010. **125**(6S).
10. Urbanchek MG, L.L., Wellington MS, Egeland BE, Marcelo CL, Martin DC, Kuzon, Jr WM, Cederna PS *Myoblast Compatibility With A Bio-synthetic Electrically Conductive Material*. *Plastic & Reconstructive Surgery*, 2008. **121**(6S).
11. Peramo, A., et al., *In situ polymerization of a conductive polymer in acellular muscle tissue constructs*. *Tissue Eng Part A*, 2008. **14**(3): p. 423-32.
12. DeLongchamp, D.M., M. Kastantin, and P.T. Hammond, *High-Contrast Electrochromism from Layer-By-Layer Polymer Films*. *Chem Mater*, 2003. **15**: p. 1575-1586.
13. Chaplan, S.R., et al., *Quantitative assessment of tactile allodynia in the rat paw*. *J Neurosci Methods*, 1994. **53**(1): p. 55-63.
14. Smahel, J., *Some thoughts and observations concerning the prevention of neuroma*. *Acta chirurgiae plasticae*, 1998. **40**(1): p. 12-6.

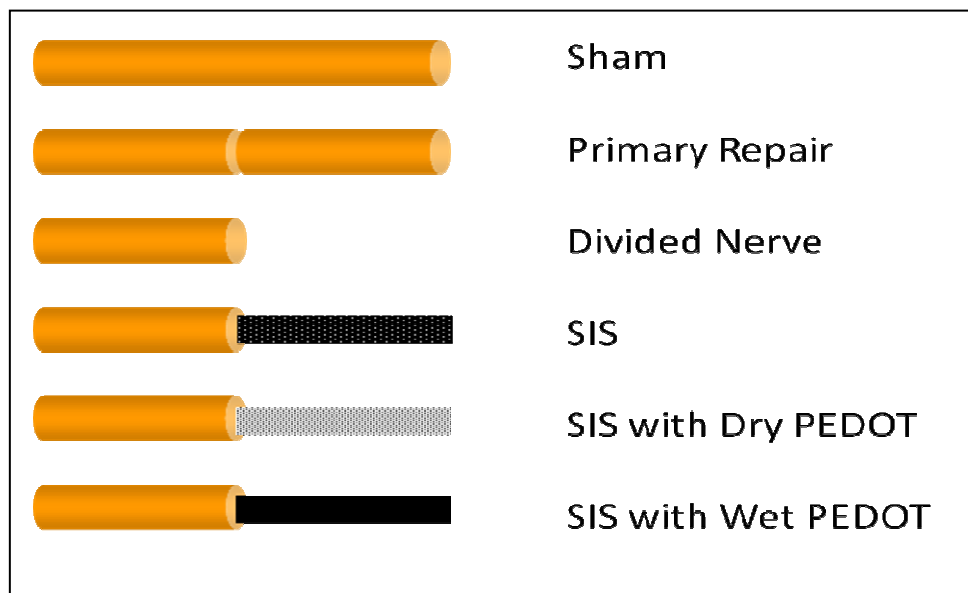


Figure 1. Experimental groups for evaluation of neuroma formation. n = 8 per group. Animals evaluated on POD 90 and 180. Abbreviations: SIS indicates Porcine small intestinal submucosa. PEDOT indicates poly(3,4-ethylenedioxythiophene).

	Sham (n = 8)	Primary Repair (n = 8)	Divided Nerve (n = 8)	SIS (n = 8)	Dry PEDOT + SIS (n = 8)	Wet PEDOT + SIS (n = 8)
3 months	0.63 g ± 0.75 g	0.62 g ± 0.96 g	0.10 g ± 0.15 g*	0.22 g ± 0.33 g	0.01 g ± 0.02 g*†	0.32 g ± 0.32 g
6 months	1.03 g ± 1.08 g	0.15 g ± 0.19 g	0.07 g ± 0.10 g*	0.20 g ± 0.30 g	0.13 g ± 0.13 g	0.15 g ± 0.15 g

Table 1. Three and six month tactile sensitivity thresholds (g) to von Frey monofilament stimulation.

Values are the mean ± 1SD for the calculated 50% gram threshold. Lower values reflect higher sensitivity. *: more sensitive than Sham, p < 0.05. †: more sensitive than SIS, p < 0.06. Abbreviations: SIS indicates Porcine small intestinal submucosa. PEDOT indicates poly(3,4-ethylenedioxythiophene).

Reassessment of “Evidence-Based Medicine”

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INTRODUCTION

There is tremendous pressure on the medical profession to lower the costs of medical care, and physicians are now being challenged to prove that their services are of quantifiable benefit to obtain payment from insurance carriers (1). Objective evidence of efficacy in hand surgery includes quantitative data, such as pinch and grip strength (2), but factual data are subject to misinterpretation. There now exists strong financial motivation within the health care system to interpret this data in such a way as to control costs, specifically by denial of payment for services that are not supported by “evidence.” The following case illustrates how easily the interpretation of seemingly straight-forward, clinically relevant, quantitative “evidence” can lead to a totally erroneous conclusion. Strict reliance on published medical “evidence” places the entire medical care system at risk for inappropriate restriction of care by payors seeking to avoid claims payment.

CASE REPORT

A healthy right-handed middle-aged male musician presented with a complaint of right “hand weakness.” A few days earlier, he experienced sudden onset of atraumatic pain in his dominant arm. This was followed the next day by inability to flex the end joints of his right thumb and index finger. There was no injury, and he did not have any history of numbness in the hand or arm, or any other illness. On physical exam he was noted to have inability to flex the FPL and the FDP of the index finger of his right hand. Grip strength on the right was 80/85/85 lbs. vs. 90/95/90 lbs on the left. Pinch strength was 12/14/14 lbs. on the right and 12/15/15 lbs. on the left. The patient was diagnosed with anterior interosseous nerve palsy, etiology unknown. EMG showed 1+ PSW in the PQ and FPL, with fibrillations in the PQ, and increased insertional activity in both muscles, and no voluntary recruitment in either muscle. There was also decreased amplitude and increased latency for the AIN in the antecubital fossa. MRI of the forearm showed edema in the FPL and PQ, consistent with denervation, and MRI of the median nerve above the elbow showed a 4cm segment of edematous nerve. No treatment was given, and the patient’s symptoms did not resolve with time.

DISCUSSION

Scientific evaluation of patients with a complaint of “hand weakness” would require quantitation of hand strength, typically by dynamometer measurements of grip and pinch strength. This patient complained of hand weakness, and this complaint reflected the AIN palsy demonstrable on physical exam. The etiology of this nerve problem remains unknown, but the diagnosis was confirmed by electrodiagnostic studies and MRI. In spite of his AIN palsy, the patient’s grip and pinch strength were normal for his age, and were almost identical for both hands. Grip strength is primarily a function of ulnar nerve innervated muscles, and would not be expected to change with an AIN palsy. The FPL and FDP IF are innervated by the AIN and are essential for normal pinch function. With an AIN palsy, patients can generate pinch strength by using the next most proximal muscles, and/or by using the ligaments of the thumb and index finger to provide resistance to force. These adaptations to AIN weakness are apparently sufficiently effective that pinch dynamometer strength measurement is maintained in spite of

a complete AIN palsy. Pinch dynamometer assessment of pinch strength therefore precludes assessment of AIN function; instead it measures the patient's adaptation to this weakness. If pinch dynamometer measurements are normal for patients with AIN palsy, how clinically significant can this measurement be, in spite of the number being an objective, hard fact? Should all patients in the medical literature whose complaints are include "hand weakness" be evaluated for AIN dysfunction by some other method, as it is not demonstrable by pinch dynamometer?

Further, if treatment were available that somehow restored this patient's AIN function, his clinical complaint would resolve, yet it would be difficult to prove by quantitative assessment of pinch or grip strength that he was better, as these measurements were normal before treatment. If one were to assess this patient solely on the basis of the quantitation of his complaints, as is often seen in chart reviews, RN/PA triage, and Independent Medical Examinations, without the benefit of examining his hand or understanding his diagnosis, one could easily conclude that this patient's hand was not significantly weak. This would imply that either the patient was exaggerating his symptoms, or lying, when in fact the technique of quantitative assessment of hand strength by grip and pinch dynamometers is seriously deficient in some non-obvious way. From a payor's perspective, the normal pinch and grip strength could be considered strong "evidence" that the patient didn't actually have a problem, and treatment might be denied on this basis.

CONCLUSION

Even seemingly simple data such as pinch and grip strength must be interpreted carefully in the context of the patient's complaints, exam, and complete diagnoses. This case demonstrates one of the underlying flaws of requiring "evidence" to demonstrate efficacy, as facts can contradict the truth. There may be poor correlation between the patient's complaints and the data used to analyze and quantitate these complaints, even in straightforward cases. Our current quantitative assessment techniques are at times inadequate relative to the complexity of the human body, and seemingly appropriate data can be misleading. As insurers require "evidence-based" treatment plans, one must carefully assess what is truly evidence, acknowledge the limits of our knowledge and understanding, and resist the misuse of facts by payors for financial purposes. Isolated facts are not necessarily "evidence" of anything.

References:

- (1) Szabo RM, MacDermid JC, Eds. Evidence Based Practice, *Hand Clinics*, 25(1) February, 2009. Philadelphia, WB Saunders
- (2) Mathiowetz V, Kashman N, Volland G, Weber K, Dowe M, Rogers S: Grip and Pinch Strength: normative data for adults. *Arch Phys Med Rehabil* 66:69-72, 1985

Congratulations

**Dr. William Ericson
receives Jules Tinel, MD
Award from the
Association of Extremity
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Dual Oblique Skin Incisions for Proximal Median Nerve Entrapment

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INTRODUCTION

Proximal Median Nerve Entrapment (PMNE) is a challenging diagnosis for many reasons: inherently vague complaints, subtle physical exam findings that are not well-described, electrodiagnostic tests are unreliable to confirm the diagnosis, and the results of surgery can be unpredictable. The anatomy around the proximal median nerve adds to the complexity of both the diagnosis and treatment, as there are multiple anatomic features in region of the elbow with the potential to cause compression of the nerve. It has been recommended that surgical decompression of the proximal median nerve, if considered, address each possible area of compression (1) (2) (3). Large incisions about the elbow permit full visualization of pertinent anatomy, but can cause seriously disfiguring scars. This paper describes the use of two small incisions which allow safe visualization of the entire proximal median nerve, with cosmetically acceptable scars.

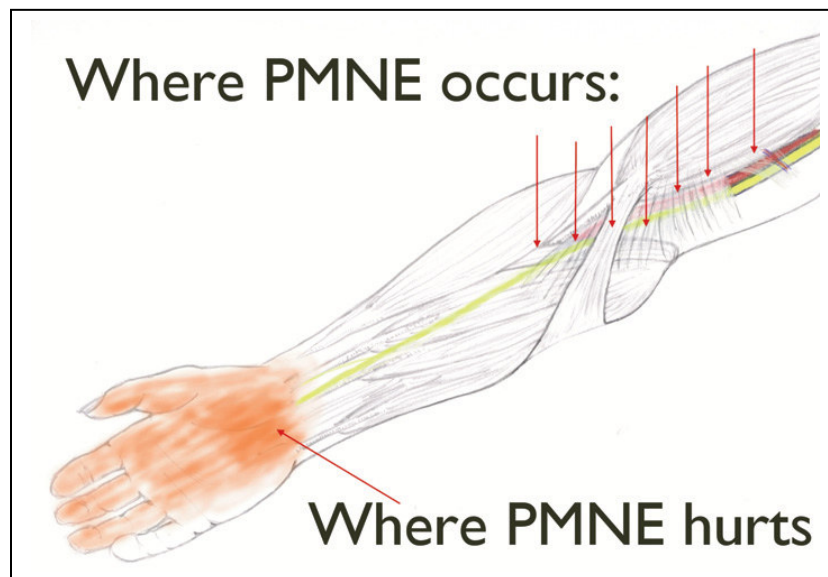


Figure 1: There are multiple sites where the proximal median nerve can be compressed. Mild compression of the proximal median nerve causes pain in the distribution of the median nerve, i.e., hand/wrist.

The author has had no problem visualizing pertinent anatomy, and has had no major complications related to scar appearance, infection, or injury to nerves or blood vessels using this technique in several hundred cases. All patients have immediate return of the strength of the FPL and FDP IF in the recovery room, and the referred pain to the wrist is also relieved in the recovery room. In addition, the anterior forearm incision is utilized for concurrent release of the radial tunnel simultaneously, if indicated.



Figure 2: Dual oblique incisions at 2 months following surgery for PMNE.

BACKGROUND

PMNE presents with complaints of "hand pain" or "wrist pain", and "hand weakness." The pain is in the distribution of the distal median nerve (ie, hand/wrist, in particular the terminal branch of the Anterior Interosseous Nerve (AIN), which innervates the volar carpus) and the pain is provoked by activities involving repetitive/sustained pronation, such as typing, writing, driving, and use of a cellphone (4). The "hand weakness" is from isolated weakness of the FPL and FDP IF, which are innervated by the AIN. The physical finding of AIN weakness localizes the site of compression at or proximal to the arch of the superficial flexors.

From proximal to distal, the sites of potential compression proximal median nerve are as follows: the Arcade of Struthers, the Fascia of Struthers, the Ligament of Struthers, the proximal fascial edge of the pronator teres muscle, the lacertus fibrosus, the deep fascia of the ulnar origin of the pronator teres muscle, the deep fascia of the humeral origin pronator teres muscle, the pronator teres muscle itself, and the fascia of the arch of the superficial flexors.

TECHNIQUE

The interval between the flexors and extensors is identified by palpation. The distal incision is 2.5cm long, oblique, centered over the median nerve, starting 3cm distal to the flexion crease of the elbow. The medial epicondyle is identified by palpation. The proximal incision is 2cm long, oblique, centered over the median nerve, ending ~3cm proximal to the medial humeral epicondyle. Under general anesthesia, the arm is exanguinated by gravity and a tourniquet inflated. Skin incisions are completed and injected with 0.25% bupivacaine. Thin, narrow retractors are used for exposure. A loupes-mounted headlight (Zeiss) is used for illumination of the surgical field. An assistant with strong arms, excellent stamina, and the ability to hold quite still is particularly helpful. The median nerve is identified proximally and followed distally, with release of any fascia in contact with the nerve. The incisions are closed with absorbable monofilament sutures and steristrips placed. Tourniquet time is approximately 20 minutes in the average size arm with no unusual anatomic variations.

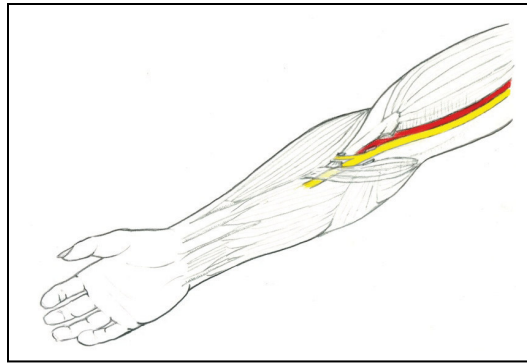


Figure 3: Deep fascia divided (fascia of ulnar origin of pronator teres, fascia of arch of superficial flexors)

RESULTS

The author has had no problem visualizing pertinent anatomy, and has had no major complications related to scar appearance, infection, or injury to nerves or blood vessels using this technique in several hundred cases. All patients have immediate return of the strength of the FPL and FDP IF in the recovery room, and the referred pain to the wrist is also relieved in the recovery room. In addition, the anterior forearm incision is utilized for concurrent release of the radial tunnel simultaneously, if indicated.

DISCUSSION

Other authors have described one large incision (3), two linear incisions (5), a transverse incision (6), and endoscopic release (7). The large incisions can widen several centimeters. The transverse incision is not disfiguring, but can make full exposure of the nerve in the forearm more difficult. Endoscopic release of the median nerve offers no advantage over the incisions this author recommends, and is inherently risky, given the anatomic variations and complexity of the forearm.

When considering treatment options for proximal median nerve entrapment, hesitation regarding surgical intervention may be reinforced because of the surgeon's concerns regarding the wide exposure needed for visualization of all sites of possible compression, and the likelihood of an unsightly scar. Small, dual oblique incisions allow adequate exposure of relevant anatomy and produce cosmetically acceptable scars. This simplified technique does not require endoscopy equipment or supplies, nor is there any postoperative casting, splinting, or therapy. The distal incision can also be used to release the radial tunnel, with similar benefits.

1. Szabo RM. Entrapment and compression neuropathies. In Green DP, Hotchkiss RN, Pederson WC, Editors. *Green's Operative Hand Surgery*. 4th ed. Philadelphia: Churchill Livingstone, 1999.
2. Szabo RM, Koo JT. Compression Neuropathies of the Median Nerve. In Slutsky DJ, Hentz VR, Editors. *Peripheral Nerve Surgery: Practical Applications in the Upper Extremity*. Philadelphia: Churchill Livingstone Elsevier. 2006.
3. Spinner M. Injuries to the major branches of Peripheral Nerves of the Forearm. Philadelphia, WB Saunders, 1978
4. Ericson WB. Diagnosis and Treatment of Median Nerve Entrapment in the Forearm. Poster presentation at the ASSH Annual Meeting, NYC, 2004.
5. Gainor BJ. Modified exposure for pronator syndrome decompression: a preliminary experience. *Orthopedics*. 1993 Dec; 16(12):1329-31
6. Tsai TM, Syed SA. A transverse skin incision for decompression of pronator teres syndrome. *J Hand Surg Br*. 1994 Feb;19(1):40-2
7. Hoffman R. Minimally Invasive and Endoscopic Techniques in Peripheral Nerve Surgery of the Hand and Forearm. In Siemionow MZ, Editor. *New Techniques in Tissue Surgery*. London: Springer-Verlag, 2006