

### SUMMARIES OF SCIENTIFIC/TECHNICAL ARTICLES

#### **Subretinal implantation of semiconductor-based photodiodes: Durability of novel implant designs**

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Evan B. Stubbs, Jr., PhD; Neal S. Peachey, PhD

**Purpose of the Work.** In developing a suitable subretinal prosthetic for long-term application to patients blinded by photoreceptor degeneration, it is necessary to identify materials that will function for a long period of time. In our prior work, we noted that gold-based devices function for only a limited period of time. This study evaluated the durability of subretinal implants in which the electrodes were composed of platinum (Pt) or iridium/iridium oxide (IrOx). **Subjects/Procedures.** Prototype microphotodiode arrays (MPAs) were placed in the subretinal space of adult cats using vitreoretinal surgical techniques. MPA function was evaluated by recording the electrical response of the implant generated in response to infrared (IR) stimulation. MPA biocompatibility was evaluated by fundus photography, by electroretinography (ERG), and by histological examination of the retina. **Results.** Up to 1 year postoperative, subretinal MPAs retained a stable position in the eye. In addition, the electrical response of the MPA did not diminish over this period of time. Electrophysiological and anatomical studies of the implanted retina indicate that the implant has good biocompatibility. **Relevance to the Veteran Population.** These results demonstrate that platinum and iridium/iridium oxide improve implant durability and indicate that these materials may be suitable for human application, in treating blinding disorders that involve photoreceptor degeneration, such as age-related macular degeneration and retinitis pigmentosa.

*Neal S. Peachey, PhD*

#### **Filter frequency selection for manual wheelchair biomechanics**

Rory A. Cooper, PhD; Carmen P. DiGiovine, PhD;  
Michael L. Boninger, MD; Sean D. Shimada, PhD;  
Alicia M. Koontz, PhD; Mark A. Baldwin, MS

**Purpose of the Work.** The purpose of this study was to analyze the signal and noise spectrum of kinematic data

collected bilaterally during manual wheelchair propulsion at two speeds and to provide guidance for the selection of an appropriate filter cutoff frequency. **Subjects/Procedures.** The subjects consisted of 28 individuals with paraplegia caused by a spinal cord injury. All were experienced in manual wheelchair use. The analysis of manual wheelchair propulsion kinematic data in the frequency domain, rather than in the time domain, allowed for the determination of key signal components used in the selection of appropriate digital filters. **Results.** Our results indicate that there is no useful signal power above 6 Hz during manual wheelchair propulsion at the speeds that we analyzed. In many cases, there was no useful signal power above 4 Hz. This would indicate that the frequency content of manual wheelchair propulsion is similar to that of human gait. **Relevance to the Veteran Population.** The study of biomechanics during wheelchair propulsion will help in understanding how to prevent injuries to veterans. Data must be collected and analyzed properly to yield useful results. This study provides guidance on the conditioning of biomechanical data.

*Rory A. Cooper, PhD*

#### **A noncontact wound measurement system**

Thomas A. Krouskop, PhD, PE; Robert Baker, PhD;  
Michael S. Wilson, MS

**Purpose of the Work.** The objective of this project was to develop and clinically validate a new generation of noncontacting wound measurement technology. The system can be used to assess wound size by characterizing the surface area and volume without touching the wound with probes or other objects that may interfere with the healing process. **Subjects/Procedures.** Adults with chronic wounds were recruited to have the camera used to record the size of their wounds. To have this done, the subjects were positioned so the wound could be seen by the camera and a series of photographs were taken to ensure that the measurements provided by the new camera system were consistent and repeatable. The measurements took less than 5 minutes in all cases and were incorporated as a part of the regular visit to the clinic. No additional time or clinic visits were required outside of the subject's regular clinic visits. **Results.** The camera system was able to measure the volume of model wounds to within 3% of the actual volume of the model. Measurements on persons were reproducible and took less than 5 minutes to complete with most measurements

being done in less than 3 minutes. The data collected with the camera were judged clinically useful by the clinicians who used the system. **Relevance to the Veteran Population.** The camera can be used to follow the healing of chronic wounds and document the rate of healing over time. This can be useful in judging how effective treatments are and may provide clinicians with better information to use when deciding whether to continue or change therapies.

*Thomas A. Krouskop, PhD, PE*

**Preliminary study of a genetically engineered spinal cord implant on urinary bladder after experimental spinal cord injury in rats**

Kyoko Sakamoto, MD; Bengt Uvelius, MD, PhD;  
Talat Khan, PhD; Margot S. Damaser, PhD

**Purpose of the Work.** Spinal cord regeneration remains an unsolved clinical problem. In addition, bladder complications from spinal cord injury cause high morbidity for spinal cord injured patients. The purpose of this study was to explore the effect of neurotrophin-secreting implants on the urinary bladder after a spinal cord contusion. **Subjects/Procedures.** Carbon filaments containing neurotrophin-secreting cells were implanted into rat spinal cords after a severe contusion. The bladders of these treated contused rats were compared to those of untreated contused rats and to those of noncontused rats. **Results.** Bladder capacity of untreated contused rats was larger than that of noncontused rats. Bladder capacity of treated rats was between that of the other two groups. These implants may lead to improved bladder structure after spinal cord contusion. **Relevance to the Veteran Population.** This study presents promising preliminary data on a new implant, which may encourage neuroregeneration and bladder recovery after spinal cord injury.

*Margot S. Damaser, PhD*

**Life satisfaction following spinal cord and traumatic brain injury: A comparative study**

Bret L. Hicken, MA; John David Putzke, PhD;  
Tom Novack, PhD; Mark Sherer, PhD;  
J. Scott Richards, PhD

**Purpose of the Work.** The purpose of this study was to examine the predictive validity of several factors that are common to spinal cord injury (SCI) and traumatic brain injury (TBI) populations to overall life satisfaction. **Subjects/Procedures.** Life satisfaction at 1-year postinjury was measured in 190 and 57 individuals with SCI and

TBI, respectively. We examined several demographic and functional predictors (1) within each group separately and (2) using both groups while controlling for unique predictors within each group. **Results.** Functional disability was the only common predictor within groups. For the TBI group, marital status was also a significant predictor of life satisfaction. None of the other predictors examined was significant among the SCI group. After the controlling of functional disability and marital status, overall life satisfaction did not differ between groups. The total explained variance in life satisfaction was low in both groups, 9% and 25% in the SCI and TBI groups, respectively. **Relevance to the Veteran Population.** The results of this study may be used to improve the health and well-being of veterans and other individuals with spinal cord injuries or traumatic brain injuries.

*Bret L. Hicken, MA*

**Outcomes from stroke rehabilitation in Veterans Affairs rehabilitation units: Detecting and correcting for selection bias**

W. Bruce Vogel, PhD; Maude Rittman, PhD;  
Patrick Bradshaw, MS; Dan Nissen;  
Leigh Anderson, MD; Barbara Bates, MD; Cliff Marshall

**Purpose of the Work.** The purpose of this study was to explore whether analyses of functional status with the use of the VA Functional Status Outcomes Database are subject to statistical selection bias, and if so, how inferences differ between standard statistical analyses and analyses corrected for such selection bias. **Subjects/Procedures.** We obtained data on 2,263 stroke patients from the 1998 Patient Treatment File and measured gains in overall, motor, and cognitive functional status using the Functional Independence Measure (FIM) for 439 patients seen on acute and subacute rehabilitation units. The results from standard multivariate models of functional gain were compared to results from multivariate models that were detected and corrected for statistical selection bias. **Results.** We found statistically significant evidence of statistical selection bias in our multivariate models of functional gain. Moreover, the inferences obtained from models that account for selection bias are markedly different from models that fail to account for the way in which the data were generated. Different patterns of statistical significance and different magnitudes of effects are observed in the models corrected for selection bias. **Relevance to the Veteran Population.** The VA collects large amounts of secondary data on its rehabilitation patients, and these data are a valuable resource for

researchers seeking to understand the effects of rehabilitation on functional gain. Analyses of such data hold tremendous promise in ensuring that appropriate interventions are targeted to appropriate patients to maximize functional status. However, it is critical for researchers to account for how the data are generated in such observational studies. Failure to do so can lead to incorrect inferences, thereby hampering our ability to understand the benefits of rehabilitation services.

*W. Bruce Vogel, PhD*

**Falls in community-dwelling stroke survivors:  
An accumulated impairments model**

Joni Stoker Yates, MPH, PT; Sue Min Lai, PhD, MBA;  
Pamela W. Duncan, PhD, PT, FAPTA;  
Stephanie Studenski, MD, MPH

**Purpose of the Work.** The purpose of this study was to examine the relationship between accumulated neurological impairments following stroke and the increased risk of falling in community-dwelling stroke survivors. **Subjects/Procedures.** Status of fall occurrences and impairments was collected for 6 months on two hundred eighty community-dwelling stroke survivors. **Results.** One hundred forty-two subjects (51%) reported a fall between 1 month and 6 months poststroke. The risk of falling increased for subjects with motor impairments; motor and sensory impairments; and motor, sensory, and visual impairments. However, the risk of falling was not linearly related to the number of impairments. Subjects with motor, sensory, and visual impairments had a lower risk of falling than did those with motor impairments only and those with motor and sensory impairments. **Relevance to the Veteran Population.** Stroke is a common neurological event, and falls are a major complication following stroke. Therefore, it is important to identify factors that increase this risk of falling in this population.

*Joni Stoker Yates, MPH, PT*

**Accuracy of a custom-designed activity monitor:  
Implications for diabetic foot ulcer healing**

Heather Hartsell, PhD, PT; Denise Fitzpatrick, BSN;  
Richard Brand, MD; Rita Frantz, PhD, RN, FAAN;  
Charles Saltzman, MD

**Purpose of the Work.** The purpose of the study was to determine the accuracy of a step activity monitor while subjects wore different kinds of footwear while walking over different surface conditions. **Subjects/Procedures.** Ten healthy subjects walked over 530 meters of flat

ground and up and down two flights of regular stairs, while wearing a running shoe or a fiberglass total contact cast (TCC). A custom-designed accelerometer (the size of a pager) was attached to the lower leg, just above the ankle. Two observers using hand-held digital counters followed the subject and recorded steps taken during all footwear and walking surface conditions. **Results.** The step activity monitor and hand-held digital counters similarly recorded steps taken for both the flat surface and stair-climbing conditions and for either footwear condition. **Relevance to the Veteran Population.** The step activity monitor provides the clinician with an accurate method to monitor activity level and subsequently to determine how it contributes to the development of foot ulceration in patients with diabetes or peripheral neuropathy. This device has been shown to be accurate during standard footwear use or during application of a TCC, conventionally used to treat foot ulcerations.

*Heather Hartsell, PhD, PT*

**A three-dimensional, anatomically detailed foot  
model: A foundation for a finite element simulation  
and means of quantifying foot-bone position**

Daniel L.A. Camacho, MD, PhD;  
William R. Ledoux, PhD; Eric S. Rohr, MS;  
Bruce J. Sangeorzan, MD; Randal P. Ching, PhD

**Purpose of the Work.** The purpose of this work was to develop the anatomical foundation for a finite-element foot model and to describe a new means of objectively quantifying foot shape. **Subjects/Procedures.** A cadaveric foot specimen was computerized tomographic (CT) scanned, and the data were used to create a three-dimensional (3-D) geometrical model of the foot. Additionally, customized software was used to calculate the principal axis of each bone and the 3-D relationships between various bones were determined. **Results.** Anatomically detailed models of the bones, cartilage, and plantar soft tissue of the foot were created. Combining the individual models resulted in a 3-D representation of the foot anatomy. The relative angles between bones were calculated. As an example, the relationship between the first metatarsal and talus is described by three Euler angles ( $z$ - $y$ - $x$ ,— $89.54^\circ$ ,  $8.55^\circ$ ,  $15.50^\circ$ ). **Relevance to the Veteran Population.** Diabetic neuropathic foot ulcers are an important concern of the veteran population. The methods described in this paper will allow for the development of future finite-element foot models. Additionally, these tools provide an object means of quantifying 3-D foot shape. The model, plus the means of quantifying foot shape, will

provide researchers with insight into foot structure and function, which will be used to improve ulcer-prevention treatment strategies.

*William R. Ledoux, PhD*

### **Implementation of an implantable joint-angle transducer**

Niloy Bhadra, MD; P. Hunter Peckham, PhD;  
Michael W. Keith, MD; Kevin L. Kilgore, PhD;  
Fred Montague, MS; Martie Gadzik, BA; Tom Stage, BA

**Purpose of the Work.** The purpose of this study was to evaluate an implantable joint angle transducer for controlling an implanted neuroprosthesis with the use of wrist joint movements. **Subjects/Procedures.** The transducer was initially tested in four dogs to evaluate safety and functionality. Following this test, the transducer was implanted surgically in two human subjects with spinal cord injury. **Results.** In the animal implants, the transducer was maintained from 10 to 19 months. The output was stable, and histology showed good implant acceptance. In the two human subjects, the transducer was successfully incorporated with their implanted neuroprosthesis and is now being used by the subjects for controlling their implanted system. **Relevance to the Veteran Population.** This type of transducer is relevant in the veteran population for control of implanted neuroprostheses, in both spinal cord injury and in stroke.

*Niloy Bhadra, MD*

### **Isometric cervical extension force and dimensions of semispinalis capitis muscle**

Asghar Rezasoltani, PhD; Jari Ylinen, MD;  
Veikko Vihko, PhD

**Purpose of the Work.** The purpose of this study was to detect the relationship between the neck semispinalis capitis muscle size and isometric cervical extension force measurements. **Subjects/Procedures.** Six ice-hockey players voluntarily participated in the study. They were from Finnish national and international junior teams. The dimensions of the muscle and the force generated by the cervical extensor muscles were simultaneously measured with a real-time ultrasonography and a custom-designed force measurement apparatus. **Results.** An increase in

neck extension force was followed by a significant increase in the dimension of the muscle. The size of the muscle was a good indicator of cervical extension force. **Relevance to the Veteran Population.** Cervical pain and disability are common problems affecting different populations. In the cervical area, using routing measurement tools may fail to provide an accurate result of the individual neck muscle function. Ultrasonography is a noninvasive method for muscle evaluation that can be useful in assessing neck pain patients and evaluating the effectiveness of a rehabilitation program.

*Asghar Rezasoltani, PhD*

### **Effects of simulated vastus medialis strength variation on patellofemoral joint biomechanics in human cadaver knees**

Thay Q. Lee, PhD; Matthew D. Sandusky, BS;  
Arshya Adeli, BS; Patrick J. McMahon, MD

**Purpose of the Work.** The objective of this study was to examine the effectiveness of isolated vastus medialis strengthening on the patellofemoral joint biomechanics in human cadaver knees. **Subjects/Procedures.** Fresh-frozen cadaveric knees were tested with the use of a custom knee system, which permits the simulation of physiologic quadriceps loading while also allowing the vastus medialis force to be varied. Patellofemoral joint kinematics were measured with a magnetic tracking device. Patellofemoral joint contact pressure and area were measured with the use of a Fuji pressure-sensitive film. **Results.** The patellofemoral joint kinematics and contact pressures were not significantly influenced by vastus medialis strength, except at extreme conditions (0% of vastus medialis strength or 150% of vastus medialis strength) in human cadaveric knees. **Relevance to the Veteran Population.** The functional range of vastus medialis strength is between 75% and 125% of the total vastus medialis strength. In human cadaveric knees, the isolated changes in vastus medialis strength in knees with loaded quadriceps may not significantly influence patellofemoral joint kinematics and patellofemoral joint contact pressures and area. Therefore, the effectiveness of isolated vastus medialis strengthening for the treatment of patellofemoral joint disorders should be revisited.

*Thay Q. Lee, PhD*