

PODIUM SESSIONS

Optimizing the sensitivity of the video head impulse test (vHIT) through catch-up saccade analysis: Can catch-up saccades, alone, be an indicator of peripheral vestibular hypofunction?

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Abstract: This study evaluated the performance characteristics of the video head impulse test (vHIT) in identifying vestibular dysfunction. This study sought to examine the sensitivity of the vHIT and to determine if catch-up saccades (CS), in the presence of normal gain, could be a predictor of a peripheral vestibulopathy.

Study Design: Retrospective review.

Methods: Electronic medical records of 171 patients referred to the University of Washington Dizziness and Balance center for a full vestibular work-up and completed vHIT testing for their dizzy symptoms were analyzed. vHIT results, specifically VOR gains and CS percentages, calorics, bedside head thrust testing, and rotary chair results along with the patient's final diagnosis were recorded. CS % optimal cut-off values were determined using the receiver-operating characteristic (ROC) curve.

Results: CS percentages were significantly greater for patients with a peripheral vestibulopathy (Mdn=65) than for patients with a central vestibulopathy (Mdn=25.5), $U=1929$, $p<0.0001$ by Mann-Whitney U test. vHIT results with normal gain and a cut-off value of 36% CS increased sensitivity of the vHIT to detect a peripheral vestibular loss from 53% to 78%.

Conclusions: Incorporating correction saccade percentage in the interpretation of vHIT improves the diagnostic accuracy in identifying a patient with a peripheral vestibulopathy.

Relationship between corrective saccades and measures of physical function in unilateral and bilateral vestibular loss

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Corrective saccades are not only a diagnostic indicator of peripheral vestibular loss but also a measure of compensatory strategy in patients with vestibulo-ocular reflex dysfunction. With recent computerization of the head impulse test (i.e., the video head impulse test, vHIT), we are now capable of describing and quantifying the amplitude and latency of the saccades (i.e., covert or overt). In some patients saccade latencies occur at similar points in time, whereas in others saccade latencies vary from head impulse to head impulse. The functional implication of these differences in latency and amplitude is unclear. Emerging evidence suggests that shorter latency (i.e, covert saccades) may be associated with improved physical function and dynamic visual acuity. Herein, we describe prevalence of saccades, saccadic amplitude, saccadic latency, and the variability in saccadic latency in a cohort of patients with unilateral ($n = 102$) and bilateral vestibular loss ($n = 20$). Additionally, associations between saccadic parameters are examined as they relate to common measures of gait, balance, physical function and symptom handicap. Results of associations and statistical modeling will be discussed.

vHIT sensitivity for Meniere's disease

Neil Shepard, PhD*, Devin McCaslin, PhD, Dennell Benson, MA

In 2017 and 2018 we reported on a study looking at the order of testing with vHIT if you had caloric, vHIT, VEMPs and rotary chair. In that study it was suggested that the sensitivity of identifying Meniere's disease (MD) was lower with vHIT than with caloric. The explanation was the possibility that secondary to hydrops expansion in the horizontal canal defeated the hydrostatic model of how caloric irrigations functioned but did not disrupt the natural response to angular acceleration as seen by vHIT. However, this only involved 16 MD patients. The present study reports on the sensitivity of vHIT and caloric irrigations to ID Meniere's with an expanded number of over 70 MD subjects and uses the length of time the patient has had spells of vertigo as a co-variable. Results suggest that the longer the patient has had MD the more sensitive vHIT is compared to caloric in the ID of MD.

The effect of disease duration on tests of hearing and balance in patients with Meniere's disease

Dennell Benson, MA**, Devin McCaslin, PhD, Neil Shepard, PhD, James McPherson, MS

Meniere's disease is a constellation of otologic symptoms that includes aural fullness, tinnitus, hearing loss, and episodic vertigo. Even though the criteria for diagnosing the disorder was set forth in 1972, the causes are still not well understood. Unfortunately, due to the degenerative nature of the disease, multiple etiologies, and the unpredictable order of symptom presentation test findings are extremely variable from patient to patient. The purpose of this retrospective study is to describe the effect of disease duration on a number of tests of vestibular and hearing function in patients diagnosed with Definite Meniere's Disease (AAO Criteria). Subjects (n=214) included in this study were taken from the Mayo Clinic Database who had an active Meniere's diagnosis within the previous 5 years. Results for each individual were obtained for cVEMP, oVEMP, caloric test findings, vHIT, sinusoidal harmonic acceleration (SHA), and hearing thresholds. Preliminary results indicate there is a significant effect of disease duration on the tests and that different tests suggest abnormal findings at different times in the disease course. These tests of vestibular function along with hearing performance will be discussed in detail.

Auditory-vestibular integration for motion perception: A psychophysical study

Corey Shayman, BS**, Erick Gallun, PhD, Robert Peterka, PhD, Yonghee Oh, PhD, Tim Hullar, MD

Spatial auditory cues can supplement vestibular cues to improve postural sway and gait. However, the mechanisms of auditory-vestibular integration are not well understood. Seven participants completed a one-interval, two-alternative forced choice direction recognition psychophysical task in the dark under three sensory conditions: whole-body yaw rotations (vestibular-only condition), yaw rotation of auditory cues with fixed body position (auditory-

only), and whole-body yaw rotations with earth-fixed auditory cues (auditory + vestibular). Perceptual thresholds were determined across a range of rotational frequencies using an adaptive procedure. Vestibular-only perceptual thresholds dominated at high frequencies, improving over the 0.1-1.0 Hz frequency range from an average of $2.05 \text{ }^\circ/\text{s} \pm 0.49 \text{ SD}$ to $0.80 \text{ }^\circ/\text{s} \pm 0.29 \text{ SD}$. Auditory-only thresholds dominated at low frequencies, worsening from an average of $0.56 \text{ }^\circ/\text{s} \pm 0.14 \text{ SD}$ to $2.48 \text{ }^\circ/\text{s} \pm 0.57 \text{ SD}$. Bayesian optimal integration threshold predictions were made from unisensory thresholds using the formula:

$1/\sigma_{\text{vestibular+auditory}} = 1/\sigma_{\text{vestibular}} + 1/\sigma_{\text{auditory}}$ and an ANOVA test confirmed bimodal (auditory + vestibular) thresholds to be statistically indistinguishable from the optimal predictions [F (1, 48) = 0.4828, P=0.4905]. The results suggest that individuals integrate auditory and vestibular cues in a frequency-dependent, statistically optimal manner, analogous to visual-vestibular integration.

The component structure of the Dizziness Handicap Inventory (DHI): A reappraisal

Kelly Van De Wyngaerde, AuD*, Minki K. Lee, PhD, Gary P. Jacobson, PhD, Devin McCaslin, PhD, Santiago Romero-Brufau, MD, Kalyan Pasupathy, PhD

The Dizziness Handicap Inventory (DHI) is a 25-item self-report questionnaire developed to measure the disabling and handicapping impact of dizziness. In the original report the authors created three subscales to assess the FUNCTIONAL and EMOTIONAL consequences of vestibular impairment. A third subscale was designed to probe the precipitating factors (PHYSICAL subscale) associated with dizziness. The subscales were created empirically without the benefit of statistical rigor. Subsequent to the original publication investigators employing statistical techniques have reported that either there was no evidence supporting subscales or, that support for subscales existed but were different than those conceived by the original investigators. The present investigation was conducted in an effort to re-assess the factor structure of the DHI using a large data set (N=1999) of dizzy patients evaluated in a tertiary care clinic. Results of the analysis revealed several findings: 1) reporting the results as a single TOTAL score (i.e. a single general factor) is warranted, and, 2) there is statistical support for the existence of up to 3 subscales representing: the physical manifestations of dizziness and vertigo, the catastrophic impact of dizziness and vertigo, and the emotional impact of dizziness and vertigo.

Development of the BPPV Symptom Impact Questionnaire

Faith W. Akin, PhD*, Sherri L. Smith, AuD, Courtney D. Hall, PhD, Kristal M. Riska, AuD, PhD, Annabelle Larkin

This session will describe the development of the BSIQ as a disease-specific quality-of-life outcome measure for BPPV. An 11-item beta version (BSIQ-b) was developed with feedback from vestibular experts who provided input on relevance, clarity, simplicity, and ambiguity. To determine initial psychometric properties, patients with BPPV completed the BSIQ-b based on their experience when they were symptomatic. A scree plot test confirmed a two-factor

solution. Factor 1, Triggers and Symptoms, consisted of 7 items primarily related to head positions that provoke vertigo. Factor 2, Impacts and Quality of Life, consisted of 3 items related to avoiding provoking symptoms and quality of life. Overall, the factor loading values were high, suggesting that the items are highly related to each other. The internal consistency reliability, Chronbach's α , was 0.93. Reliability was also assessed by evaluating inter-item correlations and ranged from fair to moderate suggesting that the items are related but not overlapping in content. Preliminary results suggest that the BSIQ-b has strong construct validity and good internal consistency reliability. Future studies will confirm the psychometric properties and expand upon the current evidence by evaluating criterion validity and test-retest reliability.

Quantification of cognitive dysfunction in dizzy patients using the Neuropsychological Vertigo Inventory

Yuan F. Liu, MD, Taylor D. Locklear, Jeffrey D. Sharon, MD, Shaun A. Nguyen, MD, Habib G. Rizk, MD*

Objective: Current questionnaires provide limited insight into cognitive dysfunction in dizzy patients. We aim to quantify this cognitive impairment using the newly developed Neuropsychological Vertigo Inventory (NVI).

Methods: All patients 18 years of older were prospectively enrolled between June and October 2018, and asked to complete the NVI, Cognitive Failure Questionnaire (CFQ), Dizziness Handicap Inventory (DHI), Generalized Anxiety Disorder-7 (GAD7) questionnaire, Patient Health Questionnaire 9 (PHQ9), and the Short Form Health Survey-20 (SF20).

Results: Of 68 subjects, 13 had BPPV, 11 had Ménière's disease (MD), and 20 had vestibular migraine (VM). VM patients were significantly younger (43.5 vs. 61.1 years, $p=0.016$), and had significantly higher GAD-7 (10.0 vs. 3.6, $p=0.025$) and NVI (67.5 vs. 51.0, $p=0.040$) scores than BPPV patients. NVI scores were similar between MD (67.3) and VM (67.5) patients ($p=1.000$). DHI scores were similar for all patients ($p=0.102$). NVI scores were highly correlated to CFQ scores ($r=0.864$, $p<0.001$).

Conclusions: VM patients have levels of cognitive dysfunction similar to MD patients, but greater than BPPV patients. A lack of difference in DHI scores among these patients reflects its limitation in assessing the cognitive domain.

Vestibular rehabilitation for acoustic neuroma: Physical therapy across the continuum of care

Jennifer Tanaka, DPT*, Lori Ginza, DPT*

Vestibular rehabilitation (VR) for unilateral vestibular hypofunction is effective at improving vestibular function and balance. The physical therapy (PT) team at USC implemented a VR program across the continuum of care with patients undergoing acoustic neuroma resection. The VR program included pre-op PT, ICU/acute PT, and outpatient PT. This consisted of discussing the role of PT during a patient's rehabilitation process, education on post-op symptoms, and implementation of gaze stabilization exercises, balance, gait and functional

activities. Intervention was customized for each patient based on individualized impairments, functional limitations, and goals. Five patients received our PT VR program across the continuum of care at USC. Average hospital length of stay was 3 days. Average number of outpatient PT visits was 9. Positive outcomes included decreased Dizziness Handicap Inventory score (average decrease of 36.5 points), improved balance and gait stability, increased score in Patient Specific Functional Scale (average increase of 5.1 points), and achievement of goal to return to work/school. We believe positive outcomes are due to early education of post-op expectations and symptoms which enhance patient participation and adherence to VR program, early initiation of gait, balance, and gaze stabilization, and customized VR program in outpatient PT.

Immersion in a virtual reality environment status-post acoustic neuroma resection: A case report assessing tolerance and stability

Lori Ginoza, DPT*, Aram Kim, MS, PT, Jennifer Tanaka, DPT, James Finley, PhD

A 22-year-old female with a right unilateral vestibular hypofunction status-post acoustic translabyrinthine resection. Outpatient physical therapy began 15 days post-op. She was a senior at an art design college with a virtual reality (VR) game design emphasis. Rehabilitation program included gaze stabilization, balance, and gait activities that were customized to address her functional goals. At 57 days post-op, she participated in a VR immersion session where the aims were to assess tolerance for VR and assess balance stability. This information was necessary to know to determine if school accommodations needed to be requested. Assessment was completed with the patient standing on a force plate in conditions of real world (RR) and VR environments. Dizziness was assessed on a 0-10 scale. Balance was measured by center of pressure (CoP) movements in RR and VR condition with head motions that simulate motions performed while engaging in a VR environment. The results indicate that immersion in VR environment increased symptoms of dizziness by 2-3 levels and contributed to decreased stability as observed by increased CoP sway in medial/lateral and anterior/posterior direction in static standing and with head movements. Recommendation for school accommodation was 5-minutes of continuous VR exposure with rest duration as needed.

Impact of vestibular rehabilitation on outcome in patients with mal de debarquement syndrome

Rebecca C. English, DPT*, Christine C. Strange, AuD, Cortney J. Van Ausdal, AuD, Yo Lin Sung, AuD, Elizabeth A. Poth, AuD, Yuan F. Liu, MD, Habib G. Rizk, MD

Objective: The role of vestibular rehabilitation (VR) is well-established in treating vestibular hypofunction, but its efficacy is unclear in mal de debarquement syndrome (MDDS). We aimed to assess VR as part of a treatment protocol for MDDS.

Methods: All MDDS patients between 10/2015 and 11/2018 were characterized. Dizziness Handicap Inventory (DHI) scores were compared before and after treatment, which included a combination of counseling, medications, and VR.

Results: There were 49 patients (78% female, mean age 49 years). 8 (16%) patients had BPPV and 7 (14%) vestibular migraine. 18 (37%) had taken venlafaxine, 15 (31%) clonazepam, 8 (16%) oral steroids, and 16 (32.7%) VR. The mean initial DHI score was 43.3+/-20.5 and the mean post-treatment DHI score was 28.7+/-22.7. There was no significant difference in change in DHI score between those who did and did not receive VR ($p=0.392$) or medications ($p=0.397$). Patients treated with medications and VR had a similar decrease (26.5) in DHI score compared to those treated with medications only (28.3, $p=0.855$), but significantly greater decrease compared to those who underwent VR only (10.4, $p=0.033$).

Conclusions: Vestibular rehabilitation alone does not result in sufficient recovery of patients with MDDS. It should be used as an adjunct of pharmacologic treatment.

Visual exploration during walking in people with mild traumatic brain injury

Bryana Popa**, Sam Stuart, Laurie King

Visual exploration of the environment is vital for safe and effective walking, and is influenced by cognitive load. Eye movement deficits can occur following mTBI and may impact visual exploration when walking, leading to issues with mobility. This study aimed to examine visual exploration when walking under single and dual-task in mTBI and controls. Five people with mTBI (Age: 32.9±13.8 yrs, days since injury: 34.4±2) and 10 healthy controls (Age: 26.3±4.9 yrs) walked for 1 minute while wearing a mobile eye tracker under single and dual-task conditions. The primary outcome was visual exploration measured by saccade frequency (sacc/sec). Secondary outcomes were saccade amplitude, peak velocity and fixation duration.

Saccade frequency was slightly reduced in mTBI compared to controls when walking and both groups reduced frequency during dual-task (mTBI; single: 1.2±0.35, dual: 1.1±0.42, control; single: 1.3±0.45, dual: 1.1±0.44). Saccade peak velocity and amplitude were greater during walking in mTBI than controls, but fixation durations were similar within all conditions.

These preliminary results indicate that visual exploration and other eye movement characteristics when walking may be impacted by mTBI. Future work will examine results in a larger cohort.

Effectiveness of vestibular therapy in the concussed adolescent athlete

Shelly Massingale, PT, MPT*, Amy Alexander, PT, Richard Allred, Steven Erickson, MD, Richard Gerkin, MD, Jamie Pardini, PhD

Purpose: The purpose of this study was to determine whether vestibular therapy (VT) resulted in improved outcomes in athletes with sport-related concussion (SRC).

Methods: Subjects were 84 concussed adolescent athletes (mean age = 15) referred for outpatient treatment of vestibular dysfunction and 132 uninjured athletes who presented for baseline assessment (mean age = 14.8). Outcomes were determined via performance on Conditions 7 (headshake on foam) and 8 (visual motion sensitivity on foam) of the Concussion Balance Test (COBALT) and through self-report of symptoms on the Post-Concussion Symptom Scale (PCSS). Data were acquired at initial and final VT visits for injured athletes and at one time point for non-injured athletes.

Results: Comparison of pre- to post-treatment data in concussed athletes revealed improvements in sway scores for C7 ($t=3.63$, $p<0.01$) and C8 ($t=6.25$, $p<0.01$). Post-treatment sway scores for SRC athletes were significantly better than in non-injured athletes for C7 ($t=3.63$, $p<0.001$), and similar to the non-injured sample for C8 ($p>0.05$). Symptom scores for the injured group improved substantially from initial to final assessment ($t=11.1$, $p<.001$), decreasing from 27.64 to 8.31.

Conclusions: Vestibular therapy can improve balance and subjective symptoms in athletes with SRC.

Vestibular, ocular, and reaction time patient's assessment in a virtual reality environment

Alex Kiderman, PhD*, Michael Hoffer, MD, Hillary Snapp, AuD, PhD, Alexandr Braverman, PhD Candidate, Carey Balaban, PhD

Background

Vestibular, Oculomotor, and Reaction Time (OVRT) testing typically require a darkened enclosure and large, often immobile video-nystagmography. A portable head mounted display with integrated eye-tracking system could simplify and lower the cost of the oculomotor/vestibular evaluation.

Goals

Evaluate the Oculomotor, Vestibular, and Reaction Time testing capability of a Portable Head Mounted Goggle with 3D Display and Integrated Eye Tracking and compare results between FDA cleared I-Portal® NOTC (Neuro-Otologic Test Center) and Portable Head Mounted Goggle (I-PASS™).

Methods

A battery of OVRT tests were run using stationary and portable systems including: horizontal and vertical saccades, smooth pursuit and gaze; optokinetic and subjective visual vertical and horizontal. A total of 82 variables were evaluated using Bland-Altman and Deming regression methods. Participants consisted of 69 controls and four mTBI subjects. All subjects were tested on both the NOTC and I-PAS systems.

Results

It was determined that no influence of sex, age, and sequences of devices had any effect. The Bland Altman and Deming regression results demonstrated significant agreement between variables using stationary and portable devices.

Conclusion

Statistical analysis demonstrates that the Portable Head-Mounted Goggle is equivalent to testing using standard clinical stationary systems. Note that FDA approval for I-PAS has been obtained.

Why we cannot get reimbursed by Medicare for VEMPs or vHIT

Robert Burkard, PhD*, Neil Shepard, PhD*, Stuart Trembath, MS*

The Center for Medicare and Medicaid Services (CMS) in no way makes it easy to develop and value new codes. New codes are needed as new procedures are developed that enhance patient care. In recent years, vestibular evoked myogenic potentials (VEMPs) have become popular for assessing otolith-organ function. Similarly, there is an emerging body of evidence that demonstrates some utility in using the video Head Impulse Test (vHIT). There are currently no procedure codes for either VEMPs or vHIT. The first part of this talk will discuss the minimum requirements for developing a new Current Procedural Terminology (CPT) code, the submission requirements for the code, and how the CPT code is valued. The second part of the talk will discuss the problems with the current fee for service approach to health care reimbursement, present a brief summary of alternative payment models (APM), and some recommendations from a recent ASHA ad hoc committee related to APMs.

Updates on vestibular migraine

Kristen K. Steenerson, MD*

The most common cause of episodic vestibular symptoms is vestibular migraine. Despite this distinction, vestibular migraine (VM) has only recently gained acceptance into the diagnostic cannon of many major medical disciplines. Due to its controversial past, VM has been hesitantly and sometimes inadequately presented and characterized in typical post-graduate training programs for providers commonly encountering vestibular disorders including those in neurology, otorhinolaryngology, audiology, physical and occupational therapies. We seek to improve the educational understanding of VM by communicating the latest updates in pathophysiology, diagnosis and treatment of VM. VM is a genetic, neurogenic, disorder. Although more common in women in their second to sixth decades, it can affect any age and sex. It likely stems from alterations in hypothalamic and brainstem sensitization with interplay in cortical spreading depression events. The diagnosis is made clinically and patients can be successfully treated with lifestyle adjustments, typical migraine medications, vestibular physical therapy and treatment of common comorbid disorders.

Impact of Tai Chi exercise on balance disorders: A systematic review

Hsin-Wei Huang**, Nanette Nicholson

Purpose: Tai Chi is receiving increasing research attention with its benefit of improving flexibility and balance. The objective of this review was to assess the evidence concerning the impact of Tai Chi as an option for vestibular rehabilitation.

Methods: Four electronic database were searched. Randomized clinical trials (RCTs) and quasi-experimental studies were included.

Results: 4 articles were included for data analysis. Results indicate positive effect of Tai Chi practice on dynamic postural stability in balance of its practitioners.

Conclusions: Tai Chi may be a useful therapy as for vestibular rehabilitation as it improves dynamic balance control and flexibility of individuals with balance and vestibular disorders.

Factors influencing gait and balance in distracted walking: Evaluating passive and active listening/communication tasks using a cell phone

Anthony T. Cacace, PhD*, Hassan Bazzi

One of the most remarkable achievements of evolution is the transition from quadrupedal-to-bipedal gait. Such a change offers the organism many advantages but in current society, also has disadvantages. Herein, we explored potential alterations in gait by increasing the complexity of cognitive, linguistic, and motor demands in tasks requiring active and passive listening/communication. Participants included 11 males; 10 females (mean age/SD: 24.4/2.6 years, 25.4/0.97 years; range: 21-31 years).

Four conditions of increasing complexity were used to examine 8 separate gait parameters while walking and using a cell phone. These conditions included: 1) walking alone, 2) walking and passive listening to a pre-recorded conversation, 3) walking and actively responding to pre-recorded questions, and, 4) walking and texting. Stimuli were delivered separately to left and right ears. Gait parameters included: velocity, cadence, stride length, ambulatory time, single-support time, and double-support time. Data were collected using the computerized GAITRite® system; extending a single 16-foot walkway to 64 feet (4x16 feet-of-distance traveled). A 2x4 repeated measures ANOVA was used to evaluate the effects of ear and condition

Significant main effects were found for velocity, ambulatory time, step count, and step velocity. There were no interactions. Discussion will focus on these variables and their implications.

Impacts of otolith dysfunction on postural stability and quality of life: A chronic effects of neurotrauma consortium study

Courtney D. Hall, PhD*, Faith W. Akin, PhD*, Owen D. Murnane, PhD, Jennifer R. Sears, AuD, Richard B. Atlee, DPT

Vestibular evoked myogenic potentials are becoming more widely used to supplement the vestibular test battery by providing information about the otolith organs and their pathways; yet, the clinical significance of otolith organ dysfunction is unclear. The purpose of this study was to determine the functional consequences of otolith organ dysfunction. A prospective case-control study of Veterans was compiled and participants were grouped according to vestibular function test findings. Three vestibular groups included: (1) otolith organ dysfunction only (n=21), (2) otolith organ and semicircular canal dysfunction (n=19), and (3) semicircular canal dysfunction only (n=12). Two control groups included individuals with normal vestibular function and (1) dizziness (n=52) or (2) no complaints of dizziness (n=26). Self-report quality of life questionnaires and physical performance measures of balance and gait were assessed. MANOVAs were performed to determine significant group differences for gait, balance and quality of life measures. Otolith organ dysfunction negatively impacted quality of life, and in conjunction with semicircular canal dysfunction, negatively impacted balance and gait. These findings have important implications for developing effective protocols for the diagnosis and management of dizziness related to otolith organ dysfunction.

Comparison of bone conduction cervical VEMPs across different transducers

Daniel J. Romero, AuD**, Erin G. Piker, AuD, PhD, Christopher Clinard, PhD, Andrew Thorne

Vestibular evoked myogenic potentials (VEMPs) can be elicited using a variety of stimulus delivery methods. Air conduction (AC) is most often used clinically; however, bone conduction (BC) offers several advantages over AC including larger response amplitudes, lower thresholds, and use in active middle ear pathologies. The frequency tuning for AC and BC VEMPs differs with better AC VEMPs reportedly occurring in the frequency range of 500 – 1000 Hz whereas BC responses are largest when elicited using lower frequencies (i.e., 500 Hz or lower). Unfortunately, clinical bone vibrators have significant output limitations for low-frequency transient tone burst stimuli required to elicit a VEMP, thus limiting the clinical utility of BC VEMPs. The purpose of this presentation is to compare BC cervical VEMPs across different bone-conduction transducers. The potential advantages and limitations of BC cVEMPs will be discussed. We will illustrate the maximum output for a transient signal from each BC transducer as a function of frequency along with recorded cVEMPs elicited using different stimuli from a sample of young normal participants. Expected outcomes will add valuable information regarding limitations and effectiveness of clinically available bone vibrators, with the goal of improving the accuracy of identifying otolith dysfunction.

Age effects of bone conduction vestibular evoked myogenic potentials (VEMPs) using B81 and reflex hammer stimuli

Jessie Patterson, AuD*, Amanda Rodriguez, PhD, Julie Honaker, PhD, Katherine Gordon, Devin McCaslin, PhD, Gary Jacobson, PhD, Kristen Janky, PhD

Cervical and ocular vestibular evoked myogenic potential (c- and oVEMPs) response rates decrease with increasing age (60+ years), making absent responses in this population challenging to interpret. Bone conduction stimuli (BCS) may provide more efficient stimulation of the otolith organs; however, traditional bone oscillation devices (i.e., B41, B71) do not produce force levels sufficient for stimulation. Recently, the B81 was developed with a higher output, but normative data is lacking. The purpose of this study was to examine response characteristics of the B81, including age effects, compared to air-conduction stimulus (ACS) and reflex hammer (RH). Healthy subjects participated (age range = 10-87 years, n= 78). cVEMP response rates were similar for ACS and B81, poorer for RH. oVEMP response rates decreased for all methods in 70+ age group, with higher response rates for BCS. For c- and oVEMPs, mixed effect modeling revealed a negative correlation between age and amplitude for all methods, as well as significant differences between ACS and BCS. Significant interactions observed for oVEMPs, with higher amplitudes for younger females and older males. Further analysis will evaluate probability of a response to BCS; however, it appears that the B81 may be a useful BC method for the clinic.

POSTER SESSION

The Frequency of Peripheral Vestibular Impairment in Independent Living/Well-Elder Communities – A Preliminary Report

Kelsey Hatton, AuD, Kathryn Makowiec, AuD, Gary Jacobson, PhD

Falls are the leading cause of injury-related visits to the emergency department for people 65 years of age and older. Approximately one third of community dwelling elders, as well as over half of nursing home residents fall each year. Vestibular system impairment is a significant risk factor for falls. Although the frequency that vestibular system impairments occur has been well-studied in elders living in assisted living centers and nursing homes comparatively less is known about vestibular impairment in independently living well-elders. The aim of this investigation was to assess the frequency that peripheral vestibular system impairment is detected in samples of independent living elders. The measures included the Dix-Hallpike and head roll tests to identify benign paroxysmal positional vertigo (BPPV) and the video head impulse test (vHIT) to identify impairments affecting the semicircular canals.

Post-Traumatic Dizziness: Navigating the Maze Toward Accurate Vestibular Diagnosis and Treatment

Melissa Grzesiak, PT, DPT*, Wendy Carender, PT, NCS

Background: Diagnosis and treatment of post-traumatic, multiple canal BPPV is complex, especially when differentiating between other possible trauma related vestibular disorders, cervicogenic dizziness, and/ or central vestibular pathology. The purpose of this study is to present a case report which demonstrates the differential diagnosis and clinical reasoning skills

utilized to identify and treat multiple origins of dizziness in a patient following a traumatic brain injury (TBI).

Methods: This patient was a 73-year-old active male and executive university director who fell off a six-foot retaining wall with positive loss of consciousness, sustaining a TBI including a right temporal bone fracture with right sided high frequency sensorineural hearing loss, a left sided subdural and subarachnoid hemorrhage, and post-traumatic multiple bilateral canal BPPV. Additional musculoskeletal injuries sustained in his fall included a right shoulder, grade 3 AC joint separation.

Results: VPT evaluation with RealEyes™ xDVR video-oculography goggles revealed BPPV involving 4 semicircular canals in addition to a 3rd degree left beating nystagmus suggestive of a unilateral vestibular hypofunction. Intervention was aimed at treating one canal per visit, beginning with the most symptomatic canal, using the appropriate canalith repositioning maneuver while modifying positioning to minimize right shoulder pain. Following successful treatment of BPPV, treatment was adjusted to facilitate central compensation utilizing gaze stabilization, habituation, and balance exercises, in addition to a daily walking program. Education was provided on how to self-assess and treat re-occurring posterior canal BPPV in addition to avoiding factors that can contribute to central decompensation. He returned 7 weeks later for his sixth visit reporting full resolution of symptoms. Dizziness Handicap Inventory Score was 54/100 initially, decreasing to 6/100 upon discharge.

Discussion/Conclusion: Scientific and clinical evidence combined with clinician expertise and selection of appropriate tests at each visit, resulted in efficient and accurate diagnosis and treatment. Due to the complexity of differentiating between multiple canal BPPV in addition to other vestibular disorders, it is imperative for the clinician to have a clear understanding of nystagmus patterns. Extensive patient education instilled self- independence and management of re-occurring BPPV and central compensation.

Feeling Superior? A Case of Anterior Canal Benign Paroxysmal Positional Vertigo Following Surgical Management of Superior Semicircular Canal Dehiscence

Richard A. Roberts, PhD*, Kathryn Makowiec, AuD*. Alejandro Rivas, MD

Objective: Benign paroxysmal positional vertigo (BPPV) is a common post-surgical finding in patients with superior semicircular canal dehiscence (SSCD). The posterior semicircular canal has been reported as the involved canal in the majority of cases, with only two cases reported of lateral canal involvement. The objective of this report is to present a case in which anterior semicircular canal BPPV was identified in a patient following surgical management for SSCD.

Method: This case presents an adult with residual dizziness following surgical management of SSCD and vestibular rehabilitation therapy. During vestibular function evaluation, a transient and torsional, down-beating nystagmus was provoked with vertigo during Dix-Hallpike right. This was consistent with BPPV affecting the left superior/anterior semicircular canal.

Results: The patient was treated with a repositioning maneuver to manage anterior semicircular canal BPPV. Review of radiographic images showed a hyperintensity in the area of the left anterior semicircular canal ampulla. It was felt this was likely a bone chip from the SSCD repair that was pushing against the ampulla.

Conclusion: It is reported that BPPV is a common complication in patients surgically managed for SSCD. The current case represents the first report of anterior semicircular canal BPPV in this type of patient.

A Symptom Based Questionnaire Compared to Expert Physicians for Vertigo and Dizziness

Bethany Watson, MS**, Devin McCaslin, PhD, Doug Totten, BS, Neil Shepard, PhD, Santiago Romero-Brufau, PhD, Kalyan Pasupathy, PhD, Jeffrey Staab, MD, Scott Eggers, MD, Colin Driscoll, MD

Dizziness is extremely common among patients and is the third most common complaint for outpatient primary care visits. This study describes a retrospective consensus-driven chart review with the ideal referrals for a cohort of 98 patients seen at a quaternary referral center. The medical records and responses of ninety-eight of these patients were retrospectively reviewed by a multidisciplinary team of experts to determine optimal appointment and testing path for these patients. The optimal path was then compared to the actual scheduled path of appointments for these patients. In our patient sample, 50% required an ENT appointment, 59% a neurology appointment, and 60% a psychiatry appointment. A high percentage (98%) required an evaluation by a subspecialist. 60% of patients had an ENT appointment scheduled, 40% a neurology appointment, and 81% a psychiatry appointment.

Types of Tasking and Their Effects on the Measurement of Slow Phase Velocity during Caloric and Rotational Chair Testing

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An essential measurement required for accurately evaluating the vestibulo-ocular reflex (VOR) in caloric irrigation and rotational chair testing is the slow phase velocity (SPV). A robust SPV measurement is needed to correctly diagnose and identify vestibular disorders and/or vestibular dysfunction. Currently, there is lack of a clearly defined tasking protocol in the literature, and the effects of different types of tasking on measurements of the SPV have been debated. The purpose of the current study is to investigate the effectiveness of different types of tasking (spatial awareness, alphabet/listing, no tasking, tactile, counting/numerical) on the SPV measurement in caloric and rotational chair testing and which, if any, proves to be the best method to obtain the most robust SPV response.

Factors Influencing the Severity of Injury from Falls in the Developmentally Disabled Adult Population

Allyson Lambert, MS**, Steven M. Doettl, AuD, Kandy Turner, MS, Patrick N. Plyler, PhD

This retrospective analysis will investigate an active fall injury database provided by the East Tennessee Regional Office of the Department of Intellectual and Developmental Disabilities (DIDD) to determine the effect of multiple falls risk factors on degree of injury related to the fall. Current research has suggested an increased risk of falls and falls with injury in the developmentally delayed adult population due to many different risk factors that have been identified such as age, familiar vs. unfamiliar environment, comorbid medical diagnoses, hearing loss, vision deficits, and impaired balance or gait. However, there is only limited data connecting these additional risks factors and the relationship with the severity of injuries. Statistical analysis using factorial ANOVA is in progress. Data from 567 fall incidents under the care and purview of DIDD over a calendar year (2016) will be analyzed for injury severity and age, active physical therapy services, staff fall instructions, staff falls training, fall prevention plans, history of falls, aggressive behaviors, medical conditions, pre-existing impaired mobility, visual deficits, hearing deficits, environment, adaptive equipment, intrinsic vs. extrinsic factors, medication changes, and obesity. Additional post-hoc analysis correlations will also be analyzed where appropriate.

Clinical Significance of the Failure to Perceive Vertigo in Post-Caloric Person Despite Robust Caloric Response

Erin Piker, AuD, PhD*, Gary P. Jacobson, PhD, Ye Wang, Kaylee Smith, AuD, Daniel J. Romero, AuD

The clinical manifestations of peripheral vestibular system impairments are well-understood. However, the symptoms of central vestibular deficits are difficult to quantify due to multisensory interactions in higher brain structures. There is convincing evidence that central vestibular impairment contributes to postural instability and cumulating evidence attesting to the strong association between the loss of vestibular function and the upstream degradation of the central nervous system resulting in cognitive deficits in visuo-spatial memory. More recently, investigations have suggested a failure to perceive motion during caloric stimulation may be indicative of a central vestibular deficit. The purpose of this study was to explore the potential association between the perception of vertigo during caloric testing, postural stability, and visuo-spatial memory. We hypothesized that patients who did not perceive motion during caloric testing would also be more unsteady on tests of functional balance and have poorer visuo-spatial memory than control patients. Results showed that absent perception was significantly associated with increased postural instability and poorer visuo-spatial memory. However, age was also associated with both outcomes and it is difficult to parse out age-effects from independent changes in central vestibular system function. The clinical relevance of the study findings and study limitations will be discussed.

Comparison of Velocity Step Test Results and Video Head Impulse Test Results in Bilateral Vestibular Loss

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Recent evidence from several research labs suggest that the video head impulse test (vHIT) is sensitive to detection of severe bilateral hypofunction but less sensitive to mild and moderate bilateral hypofunction when compared to sinusoidal harmonic acceleration (SHA). One clinical challenge encountered when using SHA is distinguishing between unilateral vestibular hypofunction and milder bilateral asymmetric hypofunction. Velocity step testing, with velocity and acceleration greater than SHA, may be useful to clarify the ambiguity. The purpose of this study was 1) to describe SHA, velocity step testing, and vHIT results in patients with bilateral weakness (n =20) and 2) to evaluate the sensitivity of vHIT in bilateral hypofunction when comparing the results to velocity step testing. ROC analyses will be undertaken and statistical modelling will be reported.

The Effect of Cochlear Implantation on Clinical Vestibular Measurements: A Retrospective Study

Allison Anderson*, Conner Rouch**, Steven Doettl, AuD, Patrick Plyler, PhD

Due to close proximity of vestibular organs and cochlear implant placement, previous research has shown before-after differences in vestibular function. The overarching idea of this study is to examine if there is a change in cervical vestibular evoked myogenic potentials (cVEMPs) due to cochlear implantation or electrical stimulation. We will analyze an existing database containing the data on patients who were seen at the University of Tennessee Audiology Clinic for pre-and post-cochlear implant vestibular evaluations and this should be finished in January. The evaluation compares cVEMPs pre-implantation to post-implantation with processor off as well as with the processor on and functioning. Our subject population focuses on young children, one to ten years of age, who have been either unilaterally or bilaterally implanted. Previous research on this topic has focused on adults and older children. Therefore, our study aims to shed light on these comparisons in the young pediatric population. Our hypothesis is that:

1. Post-implantation there will not be a change in cVEMPs when compared to pre-evaluation testing.

2. After cochlear implantation, there will not be a change in cVEMPs when cochlear implant sound processor is on compared to when the processor is off.

Downward Dog Dizziness: A Rare BPPV Case

Jenna Fenton**

Benign positional paroxysmal vertigo (BPPV) is one of the most common causes of vertigo and arises from a problem in the inner ear. Episodes of vertigo occur when calcium carbonate crystals, or otoconia, that are normally embedded in the utricle are displaced and migrate into the semicircular canals. Symptoms are typically brought on by change in head position as

gravity causes the dislodged crystals to shift. BPPV most commonly affects the posterior semicircular canals (PC-BPPV), due to their anatomical alignment and accounts for 60-90% of BPPV cases.

However, anterior canal BPPV (AC-BPPV) occurs when displaced otoconia migrate superiorly, or into the anterior semicircular canal. AC-BPPV is very rare since this semicircular canal is the highest part of the ear and it is more difficult for otoconia to travel against gravity. The prevalence of AC-BPPV is low and comprises only about 3% of all BPPV cases (Anagnostou, 2015).

The patient in this case is a 28-year-old female who reported extreme dizziness while practicing yoga, specifically in “downward dog” position. She indicated that the dizziness she experienced would last for the duration that she was in this position. An audiologic evaluation and a modified vestibular evaluation were conducted to reach a diagnosis.

“Good Balance” in Young Deaf Adults

Chizuku Tamaki, PhD*, Kristen Maul, PhD, Sarah Sparks, Emalee Danner, Noelle Allemang, Shelby Matthews

A typical systemic review at an initial encounter at a physician’s or audiologist’s office may include a question, “How is your balance?” or “Do you have any balance problems?” Congenitally or childhood onset deaf individuals have a higher prevalence of vestibular impairment; however, it is unknown whether they self-report balance problems.

Young adults (18-32 years) who self-identified to be deaf/Deaf (n=66, congenital or childhood onset) or hearing (n=22) were included in this study. Those who self-identified as hard-of-hearing and those reported a history of concussion or other neurologic deficit were not included in this study. A significant portion of deaf adults who reported their balance to be “Good – my balance is as good as average people” presented with deficits in cervical vestibular-evoked myogenic potentials (cVEMP), modified clinical test of sensory integration of balance (mCTSIB), and even the Activities-specific Balance Confidence scale (ABC), compared to the hearing adults who reported to have “Good” balance.

The results of this study raise questions regarding the functional and social impact of early onset vestibular impairments and compensation; and suggest a need for additional probing when interviewing a deaf person regarding their balance functions.

A Case Study in Leaving No Stone Unturned: Diagnosing and Resolving Persistent Postural-Perceptual Dizziness (PPPD)

Hannah Williams, AuD*, Stacie Pilgrim, AuD*, Mark Gordon, JD, MA

Patient Dillon, a 32-year-old male, presented for diagnosis and treatment, complaining of intermittent imbalance and lightheadedness as well as frequent headaches and bouts of vertigo. Symptom onset immediately following a concussion which occurred 1.5 years ago, at which time Dillon was seen by his primary care provider and by a neurologist who recommended cognitive rest. Prior medical history included depression, anxiety, and video game addiction. MRI was unremarkable. Treatments with Botox, Nortriptyline, and Namenda all failed to reduce headaches and vestibular symptoms. Vestibular assessment revealed post-traumatic vestibulopathy and otolith dysfunction (DHI: 20; cVEMP: left asymmetry 48%; oVEMP: left absent). Persistent Postural-Perceptual Dizziness (PPPD) was suspected when Dillon experienced a sudden increase in symptoms following a depressive episode. Patient then began a regimen of twice-weekly psychological talk therapy sessions and Klonopin in synergistic combination with vestibular rehabilitation with OKN stimuli. After eight weeks of combined vestibular and psychiatric therapies, reassessment showed stable vestibular function and subjective resolution of Dillon's symptoms (DHI: 2). When traditional vestibular treatments fail, there is great opportunity for the vestibular care provider to explore less-common diagnoses and advanced multidisciplinary treatment options to ensure positive symptom resolution and that no patient falls through the cracks.

A Preliminary Evaluation of Bone-Conducted Vestibular Evoked Myogenic Potentials Using the RadioEar B-81

Corey Stoelb, AuD*, Devin McCaslin, PhD, Robert Burkard, PhD

Bone conducted vestibular evoked myogenic potentials (VEMPs) are an alternative to traditional air-conducted VEMPs and may allow for the assessment of the otolith organs in a greater percentage of the population, including those with conductive hearing loss. In this study, we tested 22 subjects (to date) in order to establish normative values for bone conducted ocular and cervical VEMPs in terms of response amplitude, threshold, and interaural asymmetry, as well as amplitude difference between air- and bone-conducted stimuli with Interacoustics evoked potential software and the B-81 transducer. Also evaluated was the contribution of the occlusion effect on BC VEMPs. Preliminary results revealed that an oVEMP response was present in 90% of subjects with average thresholds of 65 dB nHL and average peak amplitude of 81 μ V at 75 dB nHL. A cVEMP response was present in 100% of subjects with an average threshold of 60 dB nHL and average peak amplitude of 231 μ V at 75 dB nHL. On average, bone conducted response amplitude was significantly larger for oVEMPs and not significantly larger for cVEMPs when compared to air conducted stimuli. There were 3 subjects (20%) with no measurable air-conducted oVEMPs but did have bone conducted oVEMPs.

In Vivo Mapping of Linear Acceleration

Srinivasu Kallakuri*, Avril Genevieve Holt*, Mirabela Hali, Andre Kuhl, Rod D. Braun

Damage to the vestibular system can manifest as dizziness, imbalance, and poor postural control. Linear acceleration has been reported to result in measurable vestibular short-latency

evoked potentials (VsEPs). Currently, central neurons that contribute to the production of VsEPs are not well delineated. Manganese acts as a calcium surrogate, accumulating in active neurons. The paramagnetic nature of manganese permits localization of active neurons. Therefore, we have combined VsEP and manganese-enhanced magnetic resonance (MEMRI) imaging to assess vestibular function and compare neuronal activity within central pathways in response to jerk stimulation (nonuniform linear acceleration). Manganese chloride was administered to anesthetized male Sprague Dawley rats (n=16) just prior to jerk stimulation of 500, 2,500, or 6,000 g/s, (3,000-6,000 total stimuli). Animals were imaged before, one day, and 14 days post, stimulation. Each jerk stimulus resulted in VsEPs with the largest amplitudes observed after 2,500 and 6,000 g/s. Vestibular nuclei had significantly elevated manganese uptake following stimulation with the greatest manganese uptake observed in animals subjected to higher magnitude jerks. Our results demonstrate graded increases in manganese uptake in vestibular nuclei corresponding to the magnitude of jerk stimulation. Both MEMRI and VsEPs are promising tools that can be developed to non-invasively assess vestibular function.