NOTSA 2009 Abstracts

S3 Utility of neuroimaging in patients with acute isolated vertigo referred to stroke unit

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Objective: To study the utility of neuroimaging (CT, TCD and MRI) in patients referred to stroke unit with acute isolated vertigo.

Method: Retrospective study at a tertiary hospital. Patients presenting with acute isolated vertigo in the last 6 years were selected from the stroke database and separated into 2 groups. One group consisted of acute posterior circulation stroke and the other carried non-stroke diagnoses, consisting of migraine vertigo (MV), benign paroxysmal positional vertigo (BPPV) and acute peripheral vestibulopathy (APV). All underwent admission from emergency department, targeted examination and one or more forms of neuroimaging (CT, TCD and MRI).

Results: Out of 457 patients, 88 with isolated vertigo were identified. Acute posterior circulation stroke was evident on either CT or MRI in 26/88 (29%). 85/88 (97%) had CT and it revealed the cause of vertigo (acute posterior circulation stroke) in 12/85 (14%). In the non-stroke group, 41/47 (87%, p=0.01) had normal TCD study, however in the stroke group, 13/24 (54%) had normal TCD study. 68/88 (77%) underwent MRI, and 38/68 (56%) had chronic ischaemic changes. When MRI was positive for chronic ischaemic changes, 28/38 (74%, p=0.23) had a non-stroke diagnosis, whereas when chronic ischaemic changes were absent 12/30 (40%) had a stroke. None had DWI changes when MRI was performed less than 10 days from symptom onset in the APV group (25/31).

Conclusion: In this selected group of patients, nearly a third had evidence of acute posterior circulation stroke on imaging. CT was often unrevealing in identifying the cause of vertigo. Most patients in the non-stroke group had a normal TCD study, but a proportion with stroke had normal TCD study. The presence of chronic ischaemic changes does not seem to correlate with finding a stroke, although the significance of this is uncertain. Bedside diagnosis of APV is as reliable as a negative early DWI.

S3 Alexander's law and the oculomotor neural integrator – breaking the law and other irritations

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In patients with nystagmus the slow phase velocity has a dependency on eye position, called Alexander's law (AL), where velocity is higher in the direction of the fast than the slow phase. AL is usually thought to be due to adaptive changes in the velocity-to-position neural integrator (NI). It is also believed to be elicited only by unphysiologic vestibular signals. We measured AL in patients with acute unilateral vestibular deficit (UVD) and in healthy subjects during unilateral cold or warm, and bilateral bithermal caloric vestibular stimulation, the latter being close to physiologic vestibular stimulation. In patients and healthy subjects AL was not linear, as previously expected. Second order fits to the velocity versus eye horizontal position data found that the second order term was significant in all experiments, such that the change in velocity in the quick phase direction was less than in the slow phase direction. AL developed faster (16s) than previously reported and

declined (80s) at a similar time like the nystagmus itself (73s). We also measured vertical and torsional eye velocity finding that horizontal gaze direction influences torsional velocity more than vertical gaze direction and that vertical velocity increased in the fast direction but did not decrease in the slow direction. So these changes cannot be explained by later occurring central processes in patients because they exist almost immediately in subjects during caloric stimulation. The rapid development of the eye position dependency calls into question whether Alexander's law is an adaptive mechanism. Rather, the results suggest that AL represents a simple failure of the velocity-to-position integrator, which is only coincidently advantageous to stabilizing gaze.

S3 Fundamental understanding of the VEMP

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Since its earliest description, the VEMP has been known to have characteristic properties: scaling in proportion to the level of background muscle activation, linear scaling with stimulus intensity and better detection using unrectified averaging. These properties can be shown to arise from the demonstrated changes in the underlying excitability of the muscle motoneurons as well as properties of averaging. A previously unrecognised property of large amplitude responses having longer latencies is also a consequence of this analysis.

S4 Which (Air-conducted) waveform is best for the VEMP, and how should it be measured?

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While the earliest report of the VEMP used 0.1 ms clicks, this is not necessarily optimal. Regulations exist about noise exposure that are also potentially relevant to this assessment. How should different waveforms be compared and on what basis should one be selected as "optimal"?

S4 Sensitivity of vestibular reflexes to the direction of head acceleration.

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VEMPs are traditionally evoked by sound, but can also be evoked by vibration and head taps. We characterised cVEMPs and oVEMPs to brief pulses of head acceleration delivered in the interaural plane at each mastoid, and found that both reflexes were sensitive to the direction of evoked head movement. We measured cVEMPs in 10 normal subjects and 10 patients with bilateral (bVL) or unilateral (uVL) vestibular loss. We also recorded oVEMPs in 10 patients with uVL. Stimuli were delivered with a handheld motor over the mastoid and produced relatively pure interaural head acceleration with little rotation. Cervical VEMPs were recorded from surface electrodes placed over the neck muscles and ocular VEMPs from electrodes placed beneath the eyes on the face. Both reflexes were sensitive to the direction of head acceleration. The cVEMP was characterised by an early positivity ipsilateral to the stimulated side (peak latency 15.1 ms) and a late positivity on the contralateral side (20.3 ms). This pattern of latencies reversed with the opposite direction of

acceleration. The oVEMPs showed the opposite pattern: an early negativity contralaterally and a late negativity ipsilaterally, which also reversed with changing direction of acceleration. These peaks were absent in patients with bVL, demonstrating their vestibular-dependence. Results in the patients with uVL confirmed that the main cVEMP projection was ipsilateral, while the main oVEMP pathway was contralateral, and showed that a single ear could detect both directions of acceleration (reflected in the response latency), though the response to medially-directed acceleration was dominant for the cVEMP. As the acceleration was primarily in the horizontal plane it is likely to have principally activated utricular receptors, and the responses are therefore likely to reflect utriculo-collic and utriculo-ocular projections. Our results show that the direction of a bone-conducted stimulus is an important determinant of the properties of both the ocular and cervical VEMP.

S5 Audiovestibular sarcoidosis

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We report on two patients with biopsy proven audiovestibular sarcoidosis. Their presentations included that of hearing impairment, vertigo and gait unsteadiness. On examination there was evidence of sensori-neural hearing loss, a positive head impulse test and gait ataxia. The clinical findings were confirmed by formal oto-neurology testing, the results of which included sensori-neural hearing loss with poor speech discrimination, semi-circular canal hypofunction and abnormal auditory brainstem responses. MRI of the brain revealed enhancement of the vestibular nerves.
Both patients responded to high dose oral corticosteroid treatment, which reinforces the importance of thorough investigation should the possibility of a reversible cause of audiovestibular dysfunction exist. A review of the pertinent literature was undertaken.

S5 A longitudinal posturographic study balance in migraineurs.

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Balance was investigated by static posturography in migraineurs without a history of vertigo during the interictal period. 25 migraineurs and age- and gender-matched controls were studied. With static posturography we measured: (1) postural sway with eyes open or closed on a platform or on foam with 4 different head positions; (2) limits of stability as patients
change their center of gravity to reach to 8 different points; (3) tandem walking.
We found that migraineurs had an offset center of gravity alignment in all conditions and their average reaction time and maximal excursions were significantly greater in the limits of stability test. In tandem walking, step width was significantly wider and walk speed was significantly slower in migraineurs. Our conclusion was that there was a slight but significant postural instability in migraineurs and it is of central vestibular origin. We invited same group of patients and controls to find out how balance deteriorated over more than a year. 19 patients and same age matched controls were re-studied exactly with the same protocol. In the 2nd study postural sway was greater or same in all conditions except one. Average reaction time, maximal excursion and directional control were all worse the second time but only the average reaction time and maximal excursion were significantly worse. With eyes closed tandem walk speed was significantly lower the second time than the first time. We concluded that the balance disorder of migraineurs not only persisted but can progressed and might indicate subclinical vestibulo-cerebellar dysfunction.

S6 The Effect of Endolymphatic Hydrops and Helicotrema Blockage on Low-Frequency Sensitivity of the Cochlea.

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Blockage of the helicotrema in guinea pigs resulted in an increase in the cochlear's sensitivity to low-frequency tones (<100 Hz) by as much as 30 dB, which we determined by measuring the threshold and low-frequency modulation of the cochlear microphonic (CM). Helicotrema blockage was produced by injecting 0.5-2μ L of sodium hyaluronate ("Healon", an inert viscous gel) into the extreme apex of the cochlea via a micropipette. Blockage was also produced in a separate series of experiments by indirectly by abolishing the endolymphatic sac to induce endolymphatic hydrops. Hydrops often causes Reissner's membrane to bloat, completely filling scala vestibuli and blocking the helicotrema. Given the high correlation between endolymphatic hydrops and Ménière's disease, it is possible that Ménière's disease results in an increased cochlear sensitivity to very low-frequency pressures. Along with producing this increased sensitivity during gel injections, there was a sustained displacement of the operating point of CM transducer *during* gel injections (or withdrawals), which could be maintained for at least 20 minutes. Gel injection into the apex of the cochlea appears to be a simple technique for investigating the effects of inner ear fluid pressure changes on hair cells, and the effect of abolishing the low-frequency shunt of the helicotrema.

S6 Cochlear implants in auditory neuropathy.

Catherine McMahon

Auditory brainstem responses (ABRs) are used to estimate hearing thresholds in infants with suspected hearing loss within the first few weeks of life. However, these are absent in individuals with auditory neuropathy despite behavioral thresholds typically falling within a mild to severe range (Starr et al., 1996; Rance et al., 2005). In these individuals, speech perception is often significantly poorer than expected from the pure tone audiogram and functional outcomes after hearing aid fitting and/or cochlear implantation are variable. Therefore, selecting the most appropriate hearing device for these individuals within 6 months of life is challenging. Previous literature suggests that both the site-of-lesion and the magnitude of temporal disruption may influence functional outcomes in these individuals.

In two separate studies, we show the role of auditory evoked potentials in identifying site-of-lesion and temporal disruption and therefore predicting functional outcomes in individuals with auditory neuropathy. The first study was a retrospective study that compared round-window electrocochleographic waveforms obtained before cochlear implantation and electrically-evoked ABRs obtained after implantation in subjects with severe-to-profound hearing loss with auditory neuropathy to identify the site-of-lesion. The second study compared electrically-evoked ABR waveforms obtained during the implantation surgery and cortical auditory evoked potentials (CAEPs) elicited by direct electrical stimulation through 3 electrodes (apical, middle and basal) of the implant 42-137 months after surgery.

S6 Hearing fluctuation is not a predictor of vertigo attacks in Meniere's disease

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Conclusion: It was not possible to predict a vertigo attack based on changes in audiometric thresholds in a group of 50 patients with Meniere's disease. **Objectives:** to determine if regular self-hearing tests would be useful as a predictor of vertigo in patients with Meniere's disease. **Method:** The study group consisted of patients who had a clinical diagnosis of definite Meniere's according to the AAOHNS criteria, a score on the Gibson scale of 7 or over and an enhanced negative summating potential on transtympanic electrocochleography. These patients were supplied with a programmable hearing aid and a portable programmer that allowed them to measure their own hearing in-situ. They were asked to measure their audiometric thresholds daily and if possible during the attacks of vertigo. **Results:** Hearing fluctuation occurred more often than expected but did not correlate with vertigo episodes. Statistical analysis showed that it would not be possible to predict an attack based on changes in hearing thresholds.

S6 The Origin of Gross Auditory Evoked Potentials.

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The waveshape of auditory and vestibular evoked potentials such as the Round Window Compound Action Potential (RW CAP), the Ocular Vestibular Myogenic Potential (oVEMP), the Post-Auricular Muscle Response (PAMR), and the Auditory Brainstem Response (ABR) can be used to diagnose pathologies affecting hearing and balance. This requires a good understanding of how and where these electrical potentials are generated. Early electrophysiologists understood the generation of extracellular potentials well, and also understood the difference between near-field and far-field potentials, which is not simply based on distance from the source. Recently, the term "Stationary Potential" has been given to an extracellular response that does not change latency or shape, but will change amplitude and polarity, when recorded from different locations throughout the volume conductor (e.g. the head), although there is little if any difference between a far-field potential and a stationary potential. We suggest that the evoked potentials listed above are far-field potentials, with little or no near-field components, despite often being termed near-field responses. We have recorded and compared acoustic responses of the VIIIth nerve in guinea pigs, from different regions within the cochlea and braincase. Our results suggests the RW CAP is generated by neural action currents of the VIIIth nerve flowing through the *dura mater*, as are the early components of the cochlear nucleus response and the ABR (as an inverted version of the RW CAP). Similarly, our recordings of the PAMR from various locations on the surface of the skin surrounding the post-auricular muscle, suggests the PAMR is generated by muscle currents terminating at the tendon. It is likely that components of the oVEMP are generated in a similar way.

S6 Dizziness and Cochlear implants

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Attune Hearing has a background in diagnostic audio-vestibular testing and has had a cochlear implant clinic since 1992. Dizziness is one of the most common side effects of cochlear implantation. Indications for CI are expanding to include more residual hearing and bilateral implantation. Hence vestibular assessment is increasing included in the CI candidacy test battery to assist choice of ear, reduce the likelihood of vestibular symptoms and assist patient counseling. This paper gives the local audit results on the incidence of vestibular symptoms in CI recipients and presents a literature review of dizziness and cochlear implants.

S6 Is superior canal dehiscence congenital or acquired?

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Superior canal dehiscence syndrome is typically diagnosed in adulthood and not in children or adolescents, but it is believed to be a developmental or congenital anomaly. This theory would predict more diagnoses earlier in life, but the evidence does not support this. We report a patient, in whom the diagnosis was made at age 37 but who had a suspicious history for the syndrome from at least age 10. We hypothesize some reasons for this late diagnosis and hope this case may have the effect to make pediatricians, ENT-doctors and neurologists seeing children to consider this syndrome, in order to help their patients to have a better life.

S6 Hearing preservation or vertigo control - What is more important for patients with Meniere's disease?

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Vertigo is the most distressing aspect of Meniere's disease and medical treatment is mostly focused on relieving this symptom. Invasive procedures that compromise hearing preservation are still widely used to treat vertigo. The rational used to decide upon destructive procedures as opposed to more conservative treatment approaches are usually based on the presence of "useful hearing". This paper will review case studies showing that hearing preservation and rehabilitation, in spite of audiological findings of "non-useful hearing", may ensure better long-term outcomes for patients with Meniere's disease.

S7 Animal model of ocular VEMP in vigil guinea pigs

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Objective: This study applied the ocular vestibular evoked myogenic potential (oVEMP) test to guinea pigs coupled with morphological examination to establish the animal model for oVEMP.
Design: Ten healthy and 10 gentamicin-treated guinea pigs were enrolled. During each test, a hand-held bone-conducted vibrator was placed on the animal's forehead. An amount of 0.05 mL of gentamicin (40 mg/mL) was injected directly overlaying, but not through, the round window membrane of the left ear. After one week, all animals underwent auditory brainstem response (ABR), caloric and VEMP tests, and were sacrificed for morphological study.
Results: All 10 healthy guinea pigs exhibited bilateral oVEMPs at the stimulus intensity of 139 dB force level (FL), with a mean threshold and latencies of peak nI and pI of 130 ± 4 dBFL, 3.17 ± 0.37ms and 4.72 ± 0.38ms, respectively. Similar to response rate, the nI-pI amplitude decreased markedly in magnitude as stimulus intensity decreased. All 10 animals administered with gentamicin (2 mg) on the left ear 1 week after surgery had oVEMPs present beneath the left eye (ipsilateral to the lesion side), whereas oVEMPs were absent and reduced beneath the right eye (opposite to the lesion side) in 7 and 3 animals, respectively. Morphological study of animals with absent oVEMPs identified substantial damage to the utricular macula, providing evidence which strongly confirms the interpretation of a recent clinical test of human vestibular function - that oVEMPs by bone-conducted vibration primarily reflect the operation of the utricular receptors.
Conclusions: This animal model of oVEMPs in guinea pigs sets the stage for investigating the pathophysiology of utricular disorders.

S7 Cervical and ocular VEMPs elicited by air- and bone-conducted stimulation in vestibular neuritis.

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Stimulation of the vestibular apparatus, by air-conducted (AC) sound or bone-conducted (BC) vibration, evokes short latency electromyographic potentials which can be recorded from the cervical (cVEMP) and ocular (oVEMP) muscle groups. In this study cVEMPs and oVEMPs were measured to AC (clicks and short tone bursts) and BC (impulsive interaural head accelerations) stimuli in 10 patients (60 ± 12 years) diagnosed with unilateral vestibular neuritis (VN). AC and BC evoked cVEMPs were recorded from the ipsilateral sternocleidomastoid muscle. OVEMPs were recorded from beneath the contralateral eye during upwards gaze for both modes of stimulation. For cVEMPs, all 10/10 patients had responses to AC stimulation of the unaffected ear. Stimulation of the affected ear produced mostly intact cVEMP responses (8/10 present). AC evoked oVEMPs were recorded in 9 patients. In 8 of the 9 patients, stimulation of the unaffected ear produced an intact oVEMP. However, in contrast to the cVEMP, AC stimulation of the affected ear rarely produced an oVEMP response (1/9). Brief impulsive head accelerations of the unaffected ear produced an intact cVEMP in all 10/10 patients. When the affected ear was stimulated the response was present in some patients (3/10). Impulse evoked oVEMPs were observed in 7/10 patients following stimulation of the unaffected ear, whereas no patients had responses following stimulation of the affected ear (0/10). While impulsive findings are similar for cVEMP and oVEMP responses, AC evoked responses are often present for cVEMPs while absent for oVEMPs. Thus, cVEMPs and oVEMPs can provide differing information on the integrity of vestibular reflex pathways during VN.

S7 The effects of frequency and polarity on the bone-conducted VEMP and OVEMP

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It has been recently demonstrated that VEMPs and OVEMPs are sensitive to the direction of impulsive head acceleration. Impulsive acceleration delivered to the mastoids produces responses with different latencies in each sternocleidomastoid (SCM) or eye (early responses in the SCM ipsilateral and the eye contralateral to the stimulus and late responses on the other sides). We investigated whether stimulation of the head using sinusoidal vibration, another form of head acceleration, changed the latency or polarity of VEMPs and OVEMPs. Sine waves with frequencies ranging from 100-500Hz of both positive and negative polarity were delivered via a Minishaker to the mastoids (4810, Bruel & Kjaer). VEMPs and OVEMPs were recorded from electrodes placed over the neck muscles and below the eyes, respectively. Detailed accelerometry was conducted to characterise the behaviour of the head during application of these stimuli. VEMPs and OVEMPs were present in all subjects in response to most stimuli and consisted of an initial positivity for the VEMP and an initial negativity for the OVEMP. At the lower frequencies, there were clear differences in latency of responses recorded on each side of the neck or face. For example, following 100 Hz, initially inward stimulus, the mean ipsilateral VEMP latency was 14.9 ms, while the mean contralateral latency was 19.4 ms. For the OVEMP, the mean ipsilateral latency was 12.9 ms, while the mean contralateral latency was 10.0 ms. As the stimulus frequency increased, the side-to-side latency difference decreased, but was still present at 500Hz. However, despite this overall pattern, there were individual differences in response latency, possibly due to variation in

the evoked head acceleration. Our results show that the direction and frequency of bone-conducted vibration are important determinants of VEMP and OVEMP properties even at relatively high frequencies.

S7 The role of utricular afferents in generating the n10 of the oVEMP and the p13 of the cVEMP to bone conducted vibration (BCV) of the midline forehead at the hairline (Fz)

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Background and Aim

In 1995 Halmagyi et al reported that bone conducted vibration at Fz (Fz BCV) results in an ***uncrossed cVEMP***, because p13 was absent in the ipsilesional sternocleidomastoid (SCM) in patients with unilateral vestibular loss. In 2007 Iwasaki et al reported that Fz BCV yielded a ***crossed oVEMP*** because n10 was reduced or absent beneath the contralesional eye in patients with unilateral vestibular loss. It is of great interest to identify, if possible, the sense organs of origin of these two responses to Fz BCV stimulation. Patients with partial loss of vestibular nerve function allow us to do that. de Burlet (1924) showed

- all afferent fibres from the utricular macula course in the superior vestibular nerve (together with a few fibres from the saccular macula) and all the fibres from the horizontal and anterior semicircular canals and
- most afferent fibres from the saccular macula course in the inferior vestibular nerve, together with all the fibres from the posterior semicircular canal.

In patients with superior vestibular neuritis (SVN) , horizontal and anterior semicircular canal function are reduced or absent, as shown by reduced or absent ipsilesional calorics and the head impulse sign in the plane of the horizontal and anterior canals for ipsilesional rotations. However the inferior vestibular nerve is still functional since the p13 of the ipsilesional cVEMP is still present. Since the horizontal and anterior canal afferents in the superior vestibular nerve have reduced or absent function, it is highly likely that the utricular afferents in the superior vestibular nerve also have reduced or absent function, whereas the saccular afferents in the inferior vestibular nerve are still functional. So the simple question is: ***what effect does dysfunction of utricular afferents alone have on n10 of the oVEMP and p13 of the cVEMP to Fz BCV stimuli.*** In 2009 Iwasaki et al reported that in 12/13 patients with SVN there was a reduction or loss of contralesional n10 of the oVEMP implying that n10 reflects contralateral utricular function. However in these patients the p13 of the cVEMP was unaffected.

Patients and Methods

In this study we sought to replicate and extend that result in a larger group of patients, using Fz BCV stimulation; testing oVEMP and cVEMPs to Fz BCV in these patients. So ***138 patients*** meeting the above criteria for SVN were tested by Fz BCV and the results were as follows

Results

1. On average the n10 beneath the contralesional eye was reduced or abolished, confirming Iwasaki et al 2009 and implying that n10 indicates contralateral utricular function
2. In the 138 patients there was on average no detectable difference between the amplitude of the ipsilesional and contralesional cVEMPs. That is a very fundamental dissociation; ***when utricular afferents are dysfunctional the n10 of the contralesional oVEMP to Fz BCV is reduced or absent whereas the p13 of the ipsilesional cVEMPs is preserved.*** That dissociation is important because there is a projection from the utricular macula to the ipsilateral SCM (Kushiro et al 1999) but for

Fz BCV stimuli that projection must be of minor importance because when the utricular macula is dysfunctional there is no detectable change of the ipsilesional p13 of the cVEMP to Fz BCV stimuli. For Fz BCV stimuli these results

- confirm the result that n10 of the oVEMP indicates contralateral utricular function
- confirm the fact that it is the ipsilesional saccular macula which is primarily responsible for the p13 of the ipsilesional cVEMP
- imply that the utricular macula must have a small role in generating the p13 of the ipsilesional cVEMP.

Conclusion
n10 of the oVEMP to Fz BCV primarily indicates the function of the contralateral utricular macula
p13 of the cVEMP to Fz BCV primarily indicates the function of the ipsilateral saccular macula

S8 Does adding otolith specific exercise to standard vestibular rehabilitation improve outcomes for adults with unilateral peripheral vestibular dysfunction?

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Background: In the labyrinth of each inner ear, otolith organs are sensitive to linear acceleration and static tilt of the head while semicircular canals are sensitive to angular acceleration. Traditionally, exercises stimulating the semicircular canals only are prescribed in standard vestibular rehabilitation protocols.
Objective: The aim of this ongoing study is to investigate the role of otolith specific exercises when added to exercises given in standard vestibular rehabilitation therapy. **Method:** A single blind randomized control study is being conducted at a tertiary referral centre. 50 Participants with unilateral peripheral vestibular dysfunction were recruited after vestibular function testing was performed, and randomized into an experimental or control group. Control group participants were given a standard vestibular therapy home exercise program. Experimental group participants received standard vestibular therapy exercise with additional exercises designed to stimulate the otolith organs. All participants were asked to perform these exercises daily for nine weeks. Pre and post home exercise therapy measurements were made. Primary outcome measures were the Dizziness Handicap Inventory and Computerized Dynamic Posturography. Secondary outcome measures include a battery of balance and gait measures and self administered questionnaires rating anxiety, stress, confidence and benefit of vestibular rehabilitation.
Results: A preliminary analysis of the first 36 of these participants was performed - mean age was 51.2(SD13.9), 61% were female, 28% had mixed otolith and canal pathology, 23% canal only,10% otolith only and 39% had inconclusive or normal vestibular function test results. Further results will be presented when re-assessments and analysis are completed by end September 2009.
Conclusion: It is anticipated that results from this study will contribute to an evidence based framework for modifying practice by physiotherapists in vestibular rehabilitation.
This trial is registered with ACTRN number 12609000284268.

S8 THE VESTIBULAR REHABILITATION BENEFIT QUESTIONNAIRE: MEASURING OUTCOME FROM VESTIBULAR REHABILITATION

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Vestibular Rehabilitation (VR) is commonly used for the treatment of dizzy patients to reduce the affect of dizziness on quality of life. It is considered the most suitable management for chronic dizziness. Findings of controlled trials provide evidence that VR improves both functional balance performance and self-reported dizziness. Until very recently there has been no tool validated as a longitudinal measure of treatment outcome to evaluate the effectiveness of VR. This is very important because the implementation of VR programmes depend on a reliable and inexpensive method of monitoring and assessing outcome. Measures of treatment outcome have many applications that are relevant to patients, clinicians, researchers and those who plan and purchase healthcare services. To this end Lucy Yardley and her colleagues in London have developed such a tool - Vestibular Rehabilitation Benefit Questionnaire (VRBQ) (Morris et al 2009).

S8 Head impulses delivered in vertical semicircular canal plane detect bilateral vestibular hypofunction in wall-eyed bilateral internuclear ophthalmoplegia

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Objective: To test vertical semicircular canal (SCC) function using head impulses delivered in the plane of each SCC pair in wall-eyed bilateral internuclear ophthalmoplegia (WEBINO)
Method: Case report, bedside video recording of eye movements with head impulses delivered in the plane of each semicircular canal pair and MRI.
Results: A 70 years old man presented with sudden onset diplopia and was found to have WEBINO. Head impulses delivered in the left anterior/ right posterior (LARP) or right anterior/ left posterior (RALP) plane directed towards each PSC detected vertical catch-up saccades consistent with bilateral PSC hypofunction, but no catch-up saccade was observed when the anterior semicircular canals (ASC) were tested. MRI revealed a pontomesencephalic infarct.
Conclusion: In WEBINO, head impulses delivered in the LARP or RALP plane detect bilateral PSC hypofunction. The ASCs are spared consistent with the current understanding of vestibulo-ocular pathways in INO.