

## **Bibliography**

### **Vestibular Assessment**

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<http://www.neurology.org>

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Hall, M., & Miller, E. (2001). Balance Function Testing. Retrieved October 5, 2007, from the World Wide Web: [http://www.audiologyonline.com/articles/pf\\_article\\_detail.asp?article\\_id=295](http://www.audiologyonline.com/articles/pf_article_detail.asp?article_id=295)

Lee, A., & Brazis, P. (2006). Localizing forms of nystagmus: symptoms, diagnosis, and treatment. *Current Neurology and Neuroscience Reports*, *6*, 414-420.

Nystagmus is a rhythmic oscillation of the eyes that may be acquired or congenital. The symptoms of acquired nystagmus include blurred vision and oscillopsia. Most patients with congenital nystagmus do not have oscillopsia symptoms. Several forms of nystagmus have localizing value and any neuroimaging should be directed to the topographic localization suggested by the morphology of the nystagmus and any accompanying localizing signs. Several optical, medical, and surgical treatments have been used with some success in specific forms of nystagmus.

Snashall, S. (1993). Vestibular testing: the current position. *The Journal of Laryngology and Otology*. *107*, 481-482.

### **Rotational Testing**

Cyr, D., Moller, C., & Moore, G. (1989). Clinical experience with the low-frequency rotary chair test. *Seminars in Hearing*, *10*(2), 172-190.

Furman, J., & Kamerer, D. (1989). Rotational responses in patients with bilateral caloric reduction. *Acta Otolaryngologica*, *108*(5-6), 355-361.

Hirsch, B. (1986). Computed Sinusoidal Harmonic Acceleration. *Ear and Hearing*, 7(3), 198-203.

Su, Y., Chiou, W., Weng, P., & Wang, H. (2000). Computerized rotational vestibular testing in subjects. *Chinese normal Medical Journal*, 63, 377-383.

Wall, C. (1990). The sinusoidal harmonic acceleration rotary chair test. *Neurologic Clinics*, 8(2), 269-285.

### **Computerized Dynamic Posturography**

Black, F.O. (1992). What can posturography tell us about vestibular function? In H. L. Pick Jr., P. van den Broek, D. C. Knill (Eds.), *Annals New York Academy of Sciences* (pp. 447-463). Washington, DC: American Psychological Association.

Conte, A., Caruso, G., & Mora, R. (1997). Static and dynamic posturography in prevalent laterally directed whiplash. *Eur Arch Otorhinolaryngol*, 254, 186-192.

Static and dynamic posturography was used to study patients who had experienced a prevalent laterally directed whiplash in a car accident. Results of both static and dynamic examinations were recorded. Findings showed that the whiplash injury had provoked shifting of the pressor center of the body toward a side that was at least indicative of the kind of cervical twist experienced, even when not corresponding to the prevalent direction of the trauma incurred.

Furman, J. (1994). Posturography: uses and limitations. *Balliere's Clinical Neurology*, 3(3), 501-513.

The field of posturography has been advanced by the development of computerized dynamic posturography, wherein a force platform has been combined with visual stimuli as a means of determining the relative importance of the various sensory inputs critical for balance, namely vision, somatosensation and vestibular sensation. When compared with other tests currently available for the assessment of vestibular function, computerized dynamic posturography is unique in that it assesses 'balance' rather than attempting to assess peripheral or central vestibular function more directly. This discussion focuses on the device manufactured by NeuroCom International, marketed under the trade name Equitest. The sensory organization portion of the test has been shown to be most useful in the assessment of patients with suspected vestibular disorders. This chapter reviews the current status of computerized dynamic

posturography based on published material. The vestibular pattern on computerized dynamic posturography has been observed in patients with ongoing vestibulospinal deficits. Another pattern has been labelled 'surface dependence' or 'combined visual-vestibular deficit'. Data suggest that 2-3 weeks after loss of unilateral peripheral vestibular function, most patients lose their vestibular pattern. Thus, posturography can provide valuable information regarding the status of compensation for a peripheral vestibular deficit. Results from computerized dynamic posturography may disagree with those from other vestibular laboratory testing, which suggests that posturography tests a different aspect of vestibular function than that assessed by electronystagmography and rotational testing. Computerized dynamic posturography does not provide localizing or lateralizing information, nor any information regarding aetiology; it does provide functional information regarding how well an individual can use their balance and an indication of the importance of a patient's balance disturbance on their activities of daily living. Also, computerized dynamic posturography provides a functional measure that is helpful in predicting the benefit that patients may expect to receive from therapeutic intervention with physical therapy.

Ghulyan, V., Paolino, M., Lopez, C., Dumitrescu, M., & Lacour, M. (2005). A new translational platform for evaluating aging or pathology-related postural disorders. *Acta Oto-Laryngologica*, 125, 607-617.

Dynamic posturography using a translational platform and new parameters for quantifying postural reactions to linear displacements were suitable for differentiating between aging and pathological effects in upright postural control. These tools should be used on a wider scale in the near future for both routine tests and rehabilitation purposes, including the prevention of falls in elderly people. Objective. To demonstrate that dynamic posturography using a translational platform and new parameters for quantifying postural reactions to linear displacements constitute a more suitable way of discriminating age and/or pathology-induced postural effects. Material and methods. Three groups of young healthy, elderly healthy and elderly unstable patients were tested on a translational platform using ramp (0.03, 0.07 and 0.1 m/s) and sinusoidal (0.25 and 0.5 Hz) stimulations. Their dynamic performances were compared to their postural evaluation on a static platform using classical stabilometric parameters (surface, length, etc.) and stabilogram\_ diffusion analysis (critical point coordinates and short-term diffusion coefficient). Results. The translational platform, the new parameters elaborated for quantifying postural reactions (energy and time for postural stabilization, phase and gain of the postural response) and the visual condition under which the subjects were tested (eyes open versus eyes closed) discriminated all groups better than the classical methods.

Miller, E., & Hall, M. (2001). Computerized dynamic posturography: clinical application & contribution in three cases. Retrieved October 5, 2007, from the World Wide Web:  
[http://www.audiologyonline.com/articles/pf\\_article\\_detail.asp?article\\_id=311](http://www.audiologyonline.com/articles/pf_article_detail.asp?article_id=311)

Monsell, E., Furman, J., Herdman, S., Konrad, H., & Shepard, N. (1997). Computerized dynamic platform posturography. *Otolaryngology-Head and Neck Surgery*, 117(4), 394-398.

Norre, M. (1993). Sensory interaction testing in platform posturography. *The Journal of Laryngology and Otology*, 107, 496-501.

Sataloff, R., Hawkshaw, M., Mandel, H., Zwislewski, A., Armour, J., & Mandel, S. (2005). Abnormal computerized posturography findings in dizzy patients with normal ENG results. *Ear Nose & Throat Journal*, 84(4), 212-214.

*The complexities of the balance system create difficulties for professionals interested in testing equilibrium function objectively. Traditionally, electronystagmography (ENG) has been used for this purpose, but it provides information on only a limited portion of the equilibrium system. Computerized dynamic posturography (CDP) is less specific than ENG, but it provides more global insight into a patient's ability to maintain equilibrium under more challenging environmental circumstances. CDP also appears to be valuable in obtaining objective confirmation of an abnormality in some dizzy patients whose ENG findings are normal. Our review of 33 patients with normal ENG results and abnormal CDP findings suggests that posturography is useful for confirming or quantifying a balance abnormality in some patients whose complaints cannot be confirmed by other tests frequently used by otologists.*

## **Vestibular Evoked Myogenic Potential**

Akin, F., Murname, O. (2004). Vestibular Evoked Myogenic Potentials (VEMP). *Clinical Topics in Otoneurology*, 1-6.

Akin, F., Murname, O. (2001). Vestibular Evoked Myogenic Potentials: Preliminary Report. *J Am Acad Audiol*, 12, 445-452.

Vestibular evoked myogenic potentials (VEMPs) are short-latency electromyograms evoked by high-level acoustic stimuli recorded from surface electrodes over the tonically contracted sternocleidomastoid (SCM) muscle. These responses are presumed to originate in the saccule. The purpose of this preliminary report is to provide an overview of our initial experience with the VEMP by describing the responses obtained in five subjects. Click-evoked VEMPs were present at short latencies in two normal-hearing subjects, one patient with profound congenital sensorineural hearing loss, and one patient with a severe sensorineural hearing loss following removal of a cerebellopontine angle tumor. The amplitude of the VEMP was influenced by the amount of background activity of the SCM muscle, stimulus level, and stimulus frequency. Tone-burst evoked responses showed an inverse relationship between stimulus frequency and response latency. VEMPs may prove to be a reliable technique in the clinical assessment of vestibular function.

Akin, F., Murname, O., & Proffitt, T. (2003). The effects of click and tone-burst stimulus parameters on the vestibular evoked myogenic potential (VEMP). *J Am Acad Audiol*, 14(9), 500-508.

Akin, F., Murname, O., Panus, P., Caruthers, S., Wilkinson, A., & Proffitt, T. (2004). The influence of voluntary tonic EMG level on the vestibular evoked myogenic potential. *Journal of Rehabilitation Research and Development*, 41(38), 473-480.

Vestibular-evoked myogenic potentials (VEMPs) are proposed as a reliable test to supplement the current vestibular test battery by providing diagnostic information about saccular and/or inferior vestibular nerve function. VEMPs are short-latency electromyograms (EMGs) evoked by high-level acoustic stimuli and recorded from surface electrodes over the tonically contracted sternocleidomastoid muscle. VEMP amplitude is influenced by the EMG level, which must be controlled. This study examined the ability of subjects to achieve the EMG target levels over a range of target levels typically used during VEMP recordings. In addition, the influence of

target EMG level on the latency and amplitude of the clickand tone-evoked VEMP was examined. The VEMP amplitude increased as a function of EMG target level, and the latency remained constant. EMG target levels ranging from 30  $\mu$ V to 50  $\mu$ V are suggested for clinical application of the VEMP.

Itoh, A., Kim, Y., Yoshioka, K., Kanaya, M., Enomoto, H., Hiraiwa, F., & Mizuno, M. (2001).

Clinical study of vestibular-evoked myogenic potentials and auditory brainstem responses in patients with brainstem lesions. *Acta Otolaryngol*, 545, 116-119.

A total of 13 patients, who were diagnosed with localized brainstem lesions using MRI, were investigated. The diagnoses were multiple sclerosis in five patients, brainstem hemorrhage in three patients, pontomedullary infarction in one patient and Wallenberg's syndrome in four patients. In addition, 42 ears of 21 normal adult volunteers were also examined. In a patient with upper brainstem lesions mainly affecting the midbrain, the auditory brainstem response (ABR) was abnormal but the vestibular-evoked myogenic potential (VEMP) was normal. In four patients with middle brainstem lesions which mainly affected the pons, both ABR and VEMP were abnormal. In five patients with lower brainstem lesions which mainly affected the medulla, the ABR was normal but the VEMP was abnormal. In those patients with middle-to-lower brainstem lesions, a disappearance of VEMP reactions, delay of the positive-negative (PN) wave, increase in PN interpeak latency and decrease in PN amplitude on the affected side were confirmed. In conclusion, the VEMP test comprises a useful new diagnostic method for identifying lower brainstem lesions.

Kuo, S., Yang, T., & Young, Y. (2005). Changes in vestibular evoked myogenic potentials after

meniere attacks. *Annals of Otolaryngology & Laryngology* 114(9), 717-721.

**Objectives:** The aim of this study was to apply videonystagmography (VNG) and vestibular evoked myogenic potential (VEMP) tests to patients with Meniere attacks, to explore the mechanics of where saccular disorders may affect the semicircular canals. **Methods:** From January 2001 to December 2003, 12 consecutive patients with unilateral definite Meniere's disease with vertiginous attacks underwent VNG for recording spontaneous nystagmus, as well as VEMP tests. **Results:** At the very beginning of the Meniere attack, the spontaneous nystagmus beat toward the lesion side in 5 patients (42%) and toward the healthy side in 7 patients (58%). Twenty-four hours later, only 6 patients (50%) showed spontaneous nystagmus beating toward the healthy side. Nevertheless, spontaneous nystagmus subsided in all patients within 48 hours. The VEMP test was performed within 24 hours of a Meniere attack; the VEMPs were normal in 4 patients and abnormal in 8 patients (67%). After 48 hours, 4 patients with initially abnormal VEMPs had resolution and return to normal VEMPs, and the other 4 patients still had absent VEMPs. **Conclusions:** Most patients (67%) with Meniere attacks revealed abnormal VEMPs, indicating that the saccule participates in a Meniere attack. This is an important idea that stimulates consideration of the mechanism of Meniere attacks.

Streubel, S., Cremer, P., Carey, J., Weg, N., & Minor, L. (2001). Vestibular-Evoked Myogenic

Potentials in the Diagnosis of Superior Canal Dehiscence Syndrome. *Acta Otolaryngol*, 545, 41-49.

Patients with superior canal dehiscence (SCD) syndrome have vertigo and oscillopsia induced by loud noises and by stimuli that result in changes in middle ear or intracranial pressure. We recorded vestibular-evoked myogenic potentials (VEMP responses) in 10 patients with SCD syndrome. The diagnosis had been confirmed in each case by evoked eye movements and by high-resolution CT scans of the temporal bones that showed a dehiscence overlying the affected superior canal. For the 8 patients without prior middle ear disease, the VEMP threshold from the dehiscent ears measured 7298 dB NHL (normal hearing level) whereas the threshold from normal control subjects was 9695 dB NHL ( $p < 0.0001$ ). The VEMP threshold measured from the contralateral ear in patients with unilateral dehiscence was 9894 dB NHL ( $p < 0.9$  with respect to normal controls). Two patients with apparent conductive hearing loss from middle ear disease, and SCD, had VEMP responses from the affected ears. In the absence of dehiscence, VEMP responses would not have been expected in the setting of conductive hearing loss. These findings confirm earlier studies demonstrating that patients with SCD syndrome have lowered VEMP thresholds. Conditions other than SCD syndrome may also lead to lowered VEMP

thresholds. Rather than being based upon a single test, the diagnosis of SCD syndrome is best established when the characteristic symptoms, signs, VEMP response, and CT imaging all indicate SCD.

Ushio, M., Matsuzaki, M., Tategoshi, H., & Murofushi, T. (2001). Click and short toneburst evoked myogenic potentials in cerebellopontine angle tumors. *Acta Otolaryngol*, 545, 133-135.

We report results of vestibular-evoked myogenic potentials (VEMPs) in patients with cerebellopontine angle tumors and compare results obtained using clicks with those obtained using 500 Hz short tone bursts (STB). We reviewed the records of 87 patients with cerebellopontine angle tumors. Clicks (0.1 ms, 95 dB nHL) were presented to all patients and STB (500 Hz, rise:fall time 1 ms, plateau time 2 ms, 95 dB nHL) were presented to 27 patients. Click-evoked VEMPs were abnormal in 69:87 patients (79%; no response in 55 patients, decreased response in 14 patients, normal response in 18 patients). STB-evoked VEMPs were abnormal in 22:27 patients (82%; no response in 18 patients, decreased response in 4 patients, normal response in 5 patients). Click- and STB-evoked VEMPs were identical in 23:27 patients (85%). Two patients showed normal STB-evoked VEMPs and decreased click-evoked VEMPs, and 2 patients showed decreased STB-evoked VEMPs and absent click-evoked VEMPs. These results confirm our previous study in a small number of patients. Vestibular afferents seem to respond better to 500 Hz STBs than to clicks.

Vanspauwen, R., Wuyts, F., & Van De Heyning, P. (2006). Validity of a new feedback method for the VEMP test. *Acta Oto-Laryngologica*, 126, 796-800.

Conclusions. We used a feedback method, based on a blood pressure manometer with inflatable cuff, to control the sternocleidomastoid muscle (SCM) contraction. To obtain comparable left-right VEMP responses, it is necessary (1) to determine which cuff pressures on both sides yield identical mean rectified voltage (MRV) values of the SCM contraction and (2) to apply these cuff pressures during the VEMP test. Objective. To investigate the effect of the SCM muscle contraction variability on the VEMP variables when applying the feedback method. Materials and methods. Subjects pushed with their jaw against the hand-held inflated cuff to generate cuff pressures of subsequently 30, 40 and 50 mmHg during a MRV and VEMP measurement. Results. When analyzing the relationship between the applied cuff pressures and the MRV values/VEMP amplitudes, we showed that (1) there was a linear relationship, (2) there was no side effect and (3) there was an interaction effect between 'side' and 'subject'. There was neither a side effect, nor an effect of the applied cuff pressure when considering the p13 latencies. As for the n23 values, there was no side effect but there was a significant difference when comparing the n23 latencies at cuff pressures of 30 vs 40 mmHg/50 mmHg.

Wang, Y., & Young, Y. (2007). Vestibular evoked myogenic potentials in chronic noise-induced hearing loss. *Otolaryngology-Head and Neck Surgery*, 137, 607-611.

**OBJECTIVE:** To investigate the effect of chronic noise exposure on vestibular-evoked myogenic potentials. **STUDY DESIGN:** Prospective study. **SUBJECTS AND METHODS:** Twenty patients with chronic noise-induced hearing loss, presenting as bilateral notched audiogram at 4 kHz, underwent audiometry, caloric, and vestibule evoked myogenic potential tests. **RESULTS:** Caloric and vestibular-evoked myogenic potential tests revealed abnormal responses in nine (45%) and 10 (50%) patients, respectively. However, when both results were considered together, the abnormal rate reached 70% (14 of 20). The hearing threshold of 4 kHz significantly associated with vestibularevoked myogenic potential results (ie, vestibular-evoked myogenic potential was abnormal in patients with greater degrees of hearing

loss), but not with caloric responses. **CONCLUSION:** Patients with bilateral 4-kHz notched audiogram and hearing threshold of 4 kHz \_ 40 dB may show abnormal (absent or delayed) vestibular-evoked myogenic potentials, indicating that the vestibular part, especially the sacculocollic reflex pathway, has also been damaged.

Welgampola, M. & Colebatch, J. (2005). Characteristics and clinical applications of vestibular evoked myogenic potentials. *Neurology*, *64*, 1682-1688.

A recent technique of assessing vestibular function, the vestibular-evoked myogenic potential (VEMP), is an otolith-mediated, short-latency reflex recorded from averaged sternocleidomastoid electromyography in response to intense auditory clicks delivered via headphones. Since their first description 10 years ago, VEMPs are now being used by investigators worldwide, and characteristic changes observed with aging and in a variety of peripheral and central vestibulopathies have been described. Additional methods of evoking VEMPs, which use air- and bone-conducted shorttone bursts, forehead taps, and short-duration transmastoid direct current (DC) stimulation, have been described, and these complement the original technique. Click-evoked VEMPs are attenuated or absent in a proportion of patients with vestibular neuritis, herpes zoster oticus, late Ménière disease, and vestibular schwannomas; their amplitudes are increased and thresholds are pathologically lowered in superior semicircular canal dehiscence presenting with the Tullio phenomenon. VEMPs evoked by clicks and DC are useful when monitoring the efficacy of intratympanic gentamicin therapy used for chemical vestibular ablation. Prolonged p13 and n23 peak latencies and decreased amplitudes have been observed in association with central vestibulopathy. VEMPs evoked by clicks are a robust, reproducible screening test of otolith function. DC stimulation enables differentiation of labyrinthine from retrolabyrinthine lesions; bone-conducted stimuli permit VEMP recording despite conductive hearing loss and deliver a relatively larger vestibular stimulus for a

## ENG/VNG

Cohen, H. (2004) Influence of otolith input on bithermal caloric responses: re-analyses of the data of Coats and Smith. *Acta Oto-Laryngologica*, *124*, 223-224.

*Letter to the Editor.*

Maes, L., Dhooge, I., DeVel, E., D'haenens, W., Bockstael, A., & Vinck, B. (2007). Water irrigation versus air insufflation: A comparison of two caloric test protocols. *International Journal of Audiology*, *46*, 263-269.

The aim of the present study was to construct and compare two caloric test protocols, one for water irrigation, and one for air insufflation. A set of reference data was constructed and tabulated as well as the intersubject variability. The effect of age, sex, ear, and temperature, as well as a possible priming effect and order effect were investigated. Forty-seven subjects (18 \_58 years) without otological or vestibular history participated. Four response parameters were investigated: slow component velocity (SCV), frequency, unilateral weakness (UW), and directional preponderance (DP). Statistically higher SCV values were obtained for water compared to air, with statistically higher standard deviations for SCV water values. No influences of age, sex, ear, or temperature could be demonstrated on any of the response parameters. The same applied for the presence of an order effect and a priming effect. Comparing

the two protocols to one another led the present authors to favour water as the standard irrigation medium, and air only in situations where water is contra-indicated.

Shoup, A. & Townsley, A. (2005). *Electronystagmography*. Retrieved October 5, 2007 from  
<http://www.emedicine.com/ent/topics373.htm>

Tsutsemi, T., Kitamura, K., Tsunoda, A., Yoshihiro, N., & Mitsuhashi, M. (2001).

Electronystagmographic findings in patients with cerebral degenerative disease. *Acta Otolaryngol*, 545, 136-139.

Cerebral degenerative diseases produce a variety of abnormal neuro-otological findings on electronystamography (ENG). To assess their diagnostic value and determine which manifestations are helpful in making a diagnosis, ENG findings from 72 cases of confirmed cerebral degenerative disease were analyzed. We observed a high incidence of saccadic pursuit and upward ocular dysmetria, which is likely to be useful in diagnosing cerebral degenerative disease. In contrast, moderate incidences of horizontal ocular dysmetria, gaze-evoked and rebound nystagmus, vertical positioning nystagmus and impaired visual suppression appeared to reflect the degree of dysfunction, while optokinetic nystagmus appeared to reflect both the presence of disease and its severity. Cases of spinocerebellar ataxia 6 and spinocerebellar ataxia 3 tended to produce horizontal and vertical gaze-evoked nystagmus, whereas progressive supranuclear palsy produced a higher incidence of upward gaze-evoked nystagmus, and positioning nystagmus at the sagittal plane appeared frequently in cases of non-hereditary spinocerebellar degeneration.

### **Dizziness Handicap Inventories**

Jacobson, G., & Calder, J. (1998). A screening version of the Dizziness Handicap Inventory (DHI-S). *The American Journal of Otolaryngology*, 19, 804-808.