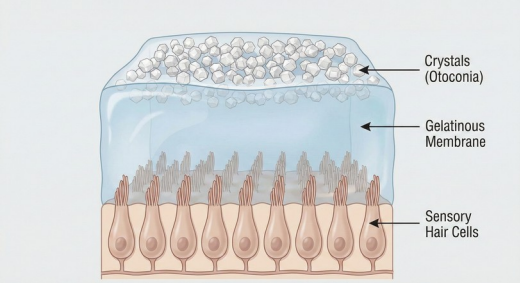
Otoconial Function and Its Measurement — Clinical Cheat Sheet

OVERVIEW & OTOLITH ORGAN PHYSIOLOGY



Otolith Organs: Utricle and saccule are the otolith organs that detect linear acceleration and head position relative to gravity. Critical for postural control, gravity reference, and spatial orientation.

Utricle vs Saccule: Utricle detects horizontal plane acceleration and head tilt; innervated by superior vestibular nerve. Saccule detects vertical plane acceleration (jumps, falls); innervated by inferior vestibular nerve.

Otoconia: Calcium carbonate crystals embedded in the gelatinous otolithic membrane. Their inertial mass causes shearing of hair cell stereocilia during linear acceleration. Displacement of otoconia causes BPPV.

Clinical Significance: Otolith dysfunction causes tilting illusions, veering gait, postural instability, chronic disequilibrium, and spatial disorientation. Often underdiagnosed as symptoms are less dramatic than canal disorders.

ANATOMY & PHYSIOLOGY OF THE OTOLITH SYSTEM

Structure	Location	Sensory Input	Nerve Supply
Utricle	Horizontal plane in vestibule	Horizontal linear acceleration, head tilt	Superior vestibular nerve
Saccule	Vertical plane in vestibule	Vertical linear acceleration, jumps/falls	Inferior vestibular nerve
Otoconia (crystals)	Embedded in otolithic membrane	Inertial mass for motion transduction	Indirect — via hair cell deflection
Type I Hair Cells	Central striola region	High sensitivity, phasic response	Calyx afferent (irregular firing)
Type II Hair Cells	Peripheral macula region	Lower sensitivity, tonic response	Bouton afferent (regular firing)

CLINICAL ASSESSMENT PROTOCOL

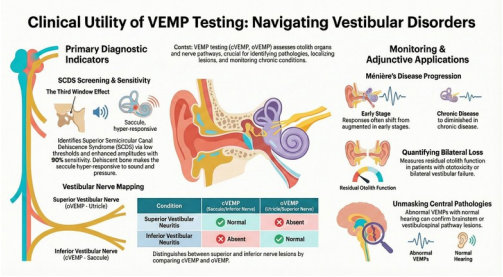
A. cVEMP (Cervical VEMP): Air-conducted tone bursts (500 Hz, 95 dB nHL) to ipsilateral ear. Patient maintains tonic SCM contraction (head turn). Measures saccular-inferior vestibular nerve function via inhibitory EMG response (P13-N23).

B. oVEMP (Ocular VEMP): Air or bone-conducted stimulus (500 Hz). Patient gazes upward (>25° elevation) to activate inferior oblique. Measures utricular-superior vestibular nerve function via contralateral excitatory response (N10).

C. SVV/SVH: Subjective Visual Vertical: patient adjusts illuminated rod to perceived vertical in darkness. Deviation >2° is abnormal; >10° indicates acute otolith dysfunction. Also test Subjective Visual Horizontal.

D. Recording Tips: cVEMP: monitor background EMG (must exceed 50 µV). oVEMP: maintain upward gaze throughout. Both: test threshold and amplitude. Calculate interaural asymmetry ratio.

VEMP INTERPRETATION GUIDE



Parameter	Normal	Mild Abnormality	Severe / Diagnostic
cVEMP P13-N23 Amplitude	>50 µV (EMG-corrected)	30-50 µV (one side reduced)	<20 µV or absent (saccular loss)
oVEMP N10 Amplitude	>5 µV contralateral	2-5 µV (reduced)	<2 µV or absent (utricular loss)
oVEMP N10 Latency	<10 ms	10-12 ms (delayed)	>12 ms (retrocochlear or central)
Interaural Asymmetry (AR)	<30% difference	30-50% (moderate asymmetry)	>50% (significant unilateral deficit)
cVEMP Threshold	<95 dB nHL	95-105 dB nHL	>105 dB nHL or absent (reduced sensitivity)
SVV Deviation	<2°	2-5° (mild tilt)	>10° (acute otolith or brainstem)

DIFFERENTIAL DIAGNOSIS: OTOLITH PATHOLOGY PATTERNS

Pattern	cVEMP	oVEMP	SVV	Likely Diagnosis
Inferior nerve lesion	Absent/reduced ipsi	Normal	Normal	Inferior vestibular neuritis
Superior nerve lesion	Normal	Absent/reduced contra	Tilted ipsi	Superior vestibular neuritis
Complete unilateral	Absent ipsi	Absent contra	Tilted ipsi	Total vestibular failure (one side)
Bilateral loss	Absent bilateral	Absent bilateral	Variable	Ototoxicity, bilateral Meniere, aging
Enhanced cVEMP	Low threshold (<75 dB)	May be enhanced	Normal	Superior canal dehiscence (SCD)

CLINICAL INTERPRETATION & SPECIAL CONSIDERATIONS

Superior Canal Dehiscence: Low cVEMP threshold (<75 dB nHL) and enhanced oVEMP amplitude are hallmark findings. Third window effect produces Tullio phenomenon and autophony. Confirm with high-resolution CT temporal bone.

Meniere Disease: cVEMP may show reduced amplitude or elevated threshold on affected side during attacks. oVEMP may be abnormal between attacks. Serial VEMPs track endolymphatic hydrops progression.

Vestibular Neuritis: Superior division neuritis: abnormal oVEMP + normal cVEMP. Inferior division: abnormal cVEMP + normal oVEMP. Complete: both abnormal. Recovery pattern helps predict compensation.

Age-Related Changes: VEMP amplitudes decline with age (cVEMP: ~5%/decade, oVEMP: ~10%/decade after age 50). Otoconia degeneration increases BPPV risk. Use age-matched norms for interpretation.

Testing Pitfall: Conductive hearing loss attenuates air-conducted VEMPs. Use bone-conducted stimulation if conductive loss present. Always perform audiometry before VEMP testing.