Vestibular-Evoked Myogenic Potentials of the Masseter Muscle (MVEMPs): a review of current knowledge and future perspective.

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Abstract

Background: Masseter vestibular-evoked myogenic potentials (MVEMPs) are an emerging technique for testing the vestibulotrigeminal pathways. Their methodology and clinical usefulness are not fully defined. This narrative review summarises current evidence on MVEMPs and their role in balance disorders. **Methods:** A literature search was conducted in PubMed, Scopus and Web of Science using combinations of terms related to VEMPs and the masseter muscle. Studies addressing vestibulomasseter physiology, MVEMPSrecording characteristics, clinical applications, or comparisons with cervical and ocular VEMPs were included. **Results:** MVEMPs reflect an inhibitory otolithic reflex arising predominantly from the saccule and conveyed via the inferior vestibular nerve to medial vestibular nuclei, with crossed projections to trigeminal motor nuclei. Optimised protocols employ tonic jaw clenching with zygomatic electrode montage and high-intensity 500 Hz tone-burst or narrow-band CE-chirp stimulation, yielding P1 ≈ 11 ms and N1 ≈ 21 ms biphasic components. MVEMPSabnormalities—typically reduced amplitudes and prolonged latencies—have been reported in vestibular disorders, sometimes revealing dysfunction when cervical vestibular-evoked myogenic potentials (CVEMPs) or ocular vestibular-evoked myogenic potentials (OVEMPs) findings are normal or discordant. **Conclusions:** MVEMPs are an interesting tool for testing the vestibulotrigeminal pathway and complement CVEMPs and OVEMPs. However, adoption is constrained by dependence on masseter pre-activation, variability in protocols, and lack of normative data and diagnostic cut-offs. Standardised methodologies, larger studies, and integration with other tests, such as imaging exams and clinical assessment, are required to establish the diagnostic and prognostic role of MVEMPs.

Keywords: *Vestibular evoked myogenic potentials, masseter muscle, vestibulomasseteric pathway, vestibular neuritis.*

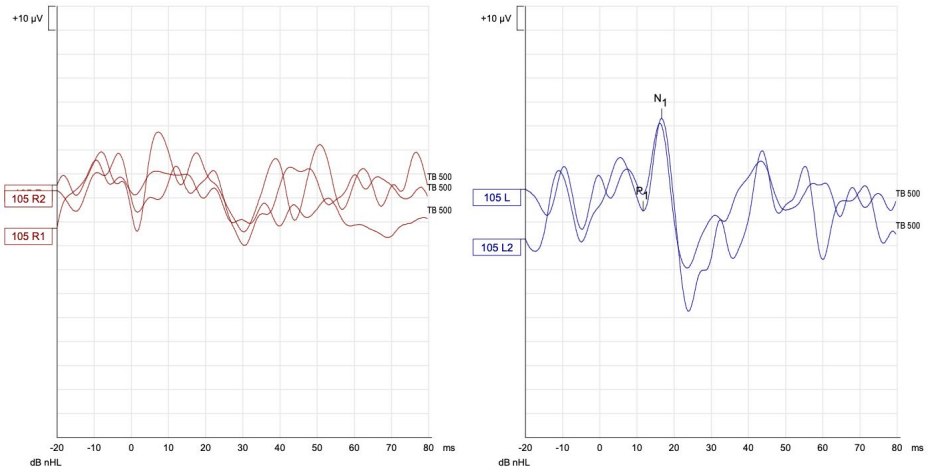
Background

Vestibular-evoked myogenic potentials (VEMPs) are an established electrophysiological method for investigating responses of the otolithic organs. They are short-latency electromyogram (EMG) potentials that can be evoked by loud air conduction sounds (Colebatch et al. 1994), bone conduction vibrations applied to the skull (Todd et al. 2007), or galvanic stimulations (Watson et al. 1998). It has been demonstrated that stimulation of the saccule and utricle can elicit myogenic responses in several muscle groups, including ocular muscles (Todd et al. 2007), cervical muscles (Wu et al. 1999), and others, such as the gastrocnemius (Rudisill and Hain 2008), soleus (Cunha et al. 2014),

triceps (Cherchi et al. 2009), trapezius, and masseter (Deriu et al. 2007).

Ocular VEMPs (OVEMPs) and cervical VEMPs (CVEMPs) are the most well-known and widely used. The first assesses the utriculoocular pathways via the extraocular muscles (Rosengren et al. 2005), whereas CVEMPs probe the sacculocollic reflex through the sternocleidomastoid muscle (Colebatch and Halmagyi 1992). In recent years, scientific interest has increasingly focused on vestibular-evoked potentials recorded from the masseter muscle (MVEMPs) (Nagarajan and Sinha 2024, Kumar et al. 2024, Ramesh and Thirunavukkarasu 2024, Thirusangu and Sinha 2023, Kılınç et al. 2023, Arkadi and Neupane 2023, Vignesh et al. 2021).

The investigation into the existence of VEMPs in the masseter and their possible clinical applications started a few decades ago. Meier-Ewert (1974) described an acoustic mandibular reflex in various cranial muscles, including the masseter. Hickenbottom (1985) was the first to demonstrate that vestibular stimulation can modulate the masseteric myogenic response. Deriu and colleagues used a transmastoid electrical stimulation to elicit EMG responses recorded in active masseter muscles. The potentials were produced by the vestibulotrigeminal reflex pathway (Deriu et al. 2003). In 2005, Deriu et al. reported the recording of masseter muscle responses to acoustic stimuli in subjects with normal hearing while the muscles were tonically active (Deriu et al. 2005). These consisted of a bilateral biphasic p11/n21 potential elicited by suprathreshold stimuli (>90 dB HL), termed the vestibular masseter response, and a second, longer-latency n16/p21 potential elicited by low-intensity stimulation (<80 dB HL), defined as the acoustic masseter response (Deriu et al. 2007). It was later demonstrated that the former potential has a vestibular (saccular) origin, whereas the n16/p21 complex originates from cochlear activity. The vestibular masseter response is a bilateral inhibitory electromyographic response resulting from activation of vestibulomasseteric pathways. These originate from the saccular maculae, travel through the inferior vestibular nerve, reach the ipsilateral medial vestibular nucleus, and, via a crossed projection, terminate in the trigeminal motor nuclei and ultimately in the masseter muscle (Deriu et al. 2007). Figure 1 shows the result of an MVEMPs testing in a 81-year-old patient affect by right vestibular neuritis (VN).



Curva	Latenze (ms)						
	P1	N1	P1'	N1'	N1-P1 Lat	N1-P1 Amp	(LA-SA)/(R+L)
105 L							
105 L2	11.67	16.67			5.00	38.64	
105 R							
105 R1							
105 R2							

Figure 1. Results of MVEMPs testing in a 81-year-old man diagnosed with right vestibular neuritis. The test shows a normal wave on the left (healthy) side and the absence of elicitable and repeatable potentials on the right (affected) side.

The clinical role of vestibular masseter responses, or MVEMPs, has been investigated in several conditions, including multiple sclerosis (Magnano et al. 2014), Parkinson's disease (De Natale et al. 2015), REM sleep disorders (De Natale et al. 2018), diabetes mellitus (Sinha and Vipinan 2025), Ménière's disease (Behmen et al. 2024), migraine (Tas Elibol et al. 2024), vestibular migraine (Sreedharan Sanitha and Sinha 2024), motion sickness (Gedik et al. 2025), and more recently in VN (Comacchio et al. 2025, Rajesh and Neupane 2024). However, evidence regarding their application in the assessment of the peripheral vestibular system—and particularly in VN—remains limited.

This review aims to summarise current knowledge of the underlying physiology, methodology, clinical relevance, open issues, and emerging perspectives on MVEMPs.

Materials and methods

This article is a narrative review of the scientific literature concerning MVEMPS. The review aimed to summarise and critically appraise the currently available knowledge on the physiology of the vestibulomasseteric pathway, and the diagnostic characteristics and clinical applications of MVEMPs. Relevant information on CVEMPs and OVEMPs was retrieved and analysed for comparisons.

A search of the PubMed, Scopus, and Web of Science databases was conducted between October and December 2025. The study search was performed using terms related to the MVEMPS and their application in clinical assessment. The following keywords and phrases were used in various combinations: "*vestibular evoked myogenic potential*", "*VEMP*", "*masseter", "MVEMP"."* to identify studies directly addressing the diagnostic utility of this test. Boolean operators ("AND", "OR") were used to refine the search. We considered studies on humans and in English language, with no time restrictions. References of the retrieved studies were scanned to identify other relevant papers.

Study Selection

Studies were reviewed to include studies that:

- Described the underlying physiology of the trigemino-vestibular pathway;
- Diagnostic utility and characteristics of MVEMPs;
- Clinical applications of MVEMPs;
- Comparisons of MVEMPs with other VEMPs.

Exclusion criteria:

- Articles solely addressing other type of VEMPs, without mention of the MVEMPs;
- Reviews or commentaries lacking primary data, unless providing theoretical insight.

Study reporting

Relevant anatomical, neurophysiological, and technical details not covered in clinical reports were supplemented with foundational literature and standard texts (e.g., otologic anatomy, auditory and vestibular neurophysiology). Bibliographic accuracy was independently verified.

This review did not involve human or animal experimentation by the authors and thus did not require ethical approval.

Results

In the following section, we aim to report the current knowledge on MVEMPs, particularly focusing on the underlying physiology, method of stimulation and recording, clinical applications, open issues and emerging perspectives.

Physiology

The masseter muscle has a primary role in mastication. It raises the mandible, plays a role in dental occlusion, and provides anti-gravity function, allowing the jaw to remain closed. As aforementioned, the study of sound-evoked vestibular responses in cranial muscles emerged in 1970s. After the studies by Meier-Ewert et al. (Meier-Ewert et al. 1974) and Hickenbottom (Hickenbottom et al. 1985), who demonstrated the relationship between vestibule and masseter, Deriu et al. (2005) published the first definitive demonstration of a vestibulomasseteric activity in humans, reporting a sound-evoked vestibulomasseteric reflex in individuals with normal hearing. These authors also described a modulation of the masseter muscle activity during both angular dynamics and tilting of the head (Hickenbottom et al. 1985, Deriu et al. 2000). This reflex has an otolithic - primarily saccular – origin, aiming to respond to unanticipated sudden head tilt (Deriu et al. 2005). The activity of this vestibulomasseteric reflex is asymmetric between the two sides and depends on head-movement orientation, providing evidence that the pathway helps maintain jaw equilibrium (Tolu and Pugliatti 1993). Furthermore, Hattori et al. (Hattori et al. 2010) reported that the otolithic organs play a role in regulating the rhythmic opening and closing phases of the jaw during mastication.

Subsequent neurophysiological experiments by the same authors (Deriu et al. 2007) confirmed that the early inhibitory potentials were abolished by vestibular but not auditory lesions, validating the vestibular source of the response. The latency profile of the masseter response—approximately 10–20 ms—was consistent with a disynaptic or trisynaptic brainstem circuit, analogous to the sacculo-collic and utriculo-ocular reflexes.

MVEMPs are generated by otolithic afferents, which project from the saccule to the vestibular nuclei. The hairy cells of the saccular macula activate the nerve fibres of neurons located in the Scarpa's ganglion, and therefore in the Inferior branch of the Vestibular nerve. These fibres contact the ipsilateral medial vestibular nucleus in the brainstem. From there, secondary neurons project to the ipsilateral and contralateral trigeminal motor nucleus via a decussation (Giaconi et al. 2006, Tolu and Pugliatti 1993), activating the masseter muscle via trigeminal motor efferents of the mandibular branch of the trigeminal nerve (Rosengren et al. 2018, Deriu et al. 2005). The vestibulomasseteric reflex pathways have been confirmed in animal studies (Cuccurazzu et al. 2007, Giaconi et al. 2006, Tolu and Pugliatti 1993). This pathway clearly distinguishes MVEMPs from CVEMPs, which reflect a sacculocollic reflex mediated by the spinal accessory nerve, although they share the same afferent origin in the saccule (Deriu et al. 2005). On the other hand, the OVEMPs primarily reflect utriculoocular projections.

Elicitation and recording of the MVEMPs

The MVEMPs waveform typically exhibits a biphasic morphology (P1/N1 or p11/n21) with short latency (~10–25 ms) and a peak-to-peak amplitude modulated by background masseter contraction. Responses are bilaterally symmetrical in healthy individuals (Vignesh et al. 2021). Under controlled conditions—moderate jaw clench, standardised EMG monitoring, and optimised stimuli—healthy adults show short-latency biphasic MVEMPs with mean P1 ≈ 11 ms and N1 ≈ 21 ms, amplitudes around 100 μV, and high bilateral response rates. Age and insufficient EMG activation are the main sources of latency prolongation and amplitude reduction. These normative data support clinical interpretation of MVEMPs abnormalities in vestibular and brainstem disorders.

After the description of the vestibular-trigeminal pathway, researchers refined both the recording technique and stimulus paradigms. Methodological studies introduced controlled tonic activation of the masseter to stabilise baseline EMG and improve reproducibility (Kılınç et al. 2023, Vignesh et al. 2021). Subsequent comparative experiments demonstrated that MVEMPs differ from CVEMPs not only in latency but also in polarity—reflecting inhibitory modulation

of the trigeminal motoneurons rather than excitatory activation of spinal motor nuclei (Rosengren et al. 2018). This distinction consolidated the understanding that the MVEMPs assess vestibulotrigeminal efferent rather than vestibulospinal projections. Furthermore, these discoveries paralleled the maturation of CVEMPs and OVEMPs as standard clinical tools, positioning the MVEMPs as a third complementary modality probing the vestibulotrigeminal network.

The MVEMPs can be recorded with both an electrical or an acoustic stimulus, as described by Deriu et al. (Deriu et al. 2005, Deriu et al. 2003). The electrical stimulus is bilateral, whereas the acoustic can active a single sided response. MVEMPs can be elicited using both air-conducted and bone-conducted vibration stimuli. BCV is particularly useful in patients with conductive hearing loss (Kumar et al. 2024). The EMG response generated in the masseter is indistinguishable in both amplitude and latency. The first (p11) peak is evoked with loud sounds. The intensity levels for elicitation of p16 peak is around 98–113 dBSPL and the intensity levels for elicitation of p11 peak is around 128–138 dBSPL (De Natale et al. 2018). Vignesh et al. (Vignesh et al. 2021) reported clear, consistent, and replicable p11 and n21 waveforms in all the forty-four subjects at 125 dB peSPL.

Different types of sounds have been applied to elicit the MVEMPS, such as clicks, chirp and tone-burst (Neupane et al. 2023, Vinayagar and Sinha 2023, Romero et al. 2022, Sangu Srinivasan et al. 2022, Thirusangu and Sinha 2022, Vignesh et al. 2021, Ginatempo et al. 2014, Deriu et al. 2007, Deriu et al. 2005). Some studies comparing different acoustic stimuli reported that tone-bursts yield robust p11/n21 peaks, with larger amplitudes and shorter latencies than conventional clicks (Nagarajan and Sinha 2024, Thirusangu and Sinha 2023, Vignesh et al. 2021). Vinayagar and Sinha (Vinayagar and Sinha 2023) reported higher peak-to-peak amplitudes using tone bursts. Low-frequency stimuli (≈500 Hz) are most effective, paralleling CVEMPs findings. Nagarajan et al. (Nagarajan et al. 2024) showed that 500-Hz narrow-band CE-chirps produce earlier latencies and larger amplitudes compared with clicks or tone bursts. The stimuli are usually delivered at a 5Hz frequency to ensure the most robust responses (Wu et al. 1999). 300-500 stimuli are generally averaged (Vignesh et al. 2021). Nagarajan and colleagues (Nagarajan et al. 2024) further defined optimal parameters—125 dB peSPL, 5 Hz repetition rate, and 0.1–3000 Hz filter bandwidth—showing consistent waveforms in over 95% of healthy subjects.

Normative datasets for adult MVEMPs latencies and amplitudes have been reported for both click- and tone-burst-evoked recordings (Kılınç et al. 2023, Vignesh et al. 2021). Test–retest reliability is moderate to high when EMG control and normalisation are employed. However, substantial inter-laboratory variability persists due to differences in stimulus type, montage, and analysis methods (Nagarajan and Sinha 2024). Reflex latencies have been reported to be shorter in females than males, whereas frequency and amplitude of VMR and AMR decrease substantially over 55-year-olds (De Natale et al. 2019). Paediatric and ageing effects remain incompletely characterised. Table 1 shows the features of stimuli used for MVEMPs elicitation.

Parameter	Recommended value	Notes
Type of acoustic stimulus	500 Hz narrow-band CE-chirp	Recent studies show shorter latency and larger amplitudes than clicks or tone-burst stimuli.
Intensity of acoustic stimulus	~125 dB peSPL (or equivalent in dB nHL)	500 Hz NB CE-chirp study used 125 dB peSPL.
Repetition rate	~5 Hz	Suggested repetition rate for optimal waveform morphology and reproducibility.

Alternative AC stimulus	500 Hz tone-burst (10 ms rise–plateau–fall)	Frequency-tuning studies recommend 500–750 Hz for tone-burst–evoked MVEMPs.
Bone-conducted vibration (BCV)	Used when air-conduction pathway is compromised	Useful in cases of conductive hearing loss or impaired sound transmission.

Table 1. Features of stimuli applied for masseter vestibular evoked myogenic potentials (MVEMPs) elicitation.

Electrode montage has also been standardised, with the active electrode placed over the inferior third of the masseter (Deriu et al. 2007, Deriu et al. 2005, Deriu et al. 2003,) and the reference at the zygomatic arch. The lower third muscle receives a more consistent innervation, yielding responses of larger magnitude (Giaconi et al. 2006). This configuration provides superior signal-to-noise ratios (Thirusangu and Sinha 2023, Romero et al. 2022). Electrode configuration significantly affects response morphology: zygomatic–forehead montages produce larger amplitudes and higher response rates than mandibular references (Nagarajan and Sinha 2024, Thirusangu and Sinha 2022, Loi et al. 2020, De Natale et al. 2019). Amplitude normalisation to background EMG is essential for reproducibility (Romero et al. 2022). Table 2 reports the indication for electrode placement and EMG control. Table 3 reports the recommended values for MVEMPs testing. Table 4 synthesises the methodological recommendations for MVEMPs testing.

Parameter	Recommended value	Notes
Active electrode	Lower third of the masseter muscle	Recommended to maximise response amplitude.
Reference electrode	Zygomatic arch	Zygomatic montage yields higher amplitudes and better response rates than mandibular montages.
Number of averages	300–500 sweeps	Typical range in acoustic-evoked MVEMPs protocols.
Pre-activation EMG control	Tonic activation of the masseter (light clenching / moderate contraction)	MVEMPs amplitude strongly depends on the level of pre-contraction.

Table 2. Electrode placing in masseter vestibular-evoked myogenic potentials (MVEMPs) testing.

Parameter	Mean ± SD	Physiological range (95%)	Key notes / references
P1 latency (ms)	11.2 ± 1.4	9.0 – 13.5	Slight latency increase with age > 50 yrs.
N1 latency (ms)	20.8 ± 2.1	17.0 – 24.5	P1–N1 complex stable across sex; mild prolongation with aging.
P1–N1 peak-to-peak amplitude (μV)	110 ± 35	50 – 180	Strongly dependent on tonic EMG level; normalization recommended.
Bilateral response rate	95 – 100 %	—	Highest with 500 Hz CE-chirp; 80–85 % with click stimuli.
Effect of age > 60 yrs	P1/N1 latencies + 1.5–2 ms; amplitude − 25–30 %	—	Reflects decreased vestibulotrigeminal excitability.
Low background EMG (< 20 μV RMS)	Amplitude reduced ≈ 50 %	—	EMG normalization mandatory for inter-session comparability.

Number of averages	400 ± 100 sweeps	300 – 500	Balance between SNR improvement and muscle fatigue.

Table 3. Reference values for masseter vestibular-evoked myogenic potentials (MVEMPs) in healthy adults

Methodological recommendations	
EMG control	Maintain tonic masseter contraction; monitor continuously and normalize amplitudes to background EMG.
Stimulus	500 Hz narrow-band CE-chirp at 125 dB peSPL (or 500 Hz tone-burst at 120 dB peSPL).
Electrode montage	Active electrode on lower third of the masseter; reference on the ipsilateral zygomatic arch (zygomatic montage).
Averaging	300–500 sweeps typically yield reproducible waveforms without excessive fatigue.
Parameters	P1/N1 latencies, P1–N1 amplitude (absolute and normalized), and interaural asymmetry ratio.

Table 4. Methodological recommendations for masseter vestibular-evoked myogenic potentials (MVEMPs) testing.

Relationship with other VEMPs

The MVEMPs are recognized as an objective measure of vestibulotrigeminal excitability, complementing the vestibulocollic and vestibuloocular reflexes that underlie CVEMPs and OVEMPs, respectively (Rosengren et al. 2018). Although MVEMPs and CVEMPs share a likely saccular origin, their efferent pathways differ—trigeminal for MVEMPs and spinal accessory for CVEMPs. The p11/p16 responses of the MVEMPS are similar to those of the CVEMPs (p13/n23) (Colebatch et al. 1994). Other similarities are the high threshold levels (Colebatch et al. 1994), the inhibitory activity (Colebatch and Rothwell 1993) and the direct correlation between the baseline EMG activity of the investigated muscles and the amplitudes of the VEMPs (Deriu et al. 2005). Studies show weak correlation between their amplitudes or asymmetry ratios, indicating distinct central processing (Vispute et al. 2023). However, the MVEMPs are bilateral potentials, and have small amplitudes than CVEMPs (Deriu et al. 2005). In VN, some patients demonstrate concordant abnormalities across both tests, while others exhibit isolated MVEMPs deficits, suggesting selective involvement of vestibulotrigeminal projections (Comacchio et al. 2025). Table 5 reports a comparison between features of MVEMPs, CVEMPs and OVEMPs.

Feature	**MVEMPs (Masseter VEMPs)**	**CVEMPs (Cervical VEMPs)**	**OVEMPs (Ocular VEMPs)**
Primary efferent muscle	Masseter (jaw elevator, innervated by trigeminal motor branch, V3)	Sternocleidomastoid (neck flexor, innervated by spinal accessory nerve)	Inferior oblique / inferior rectus (extraocular muscles, innervated by oculomotor nerve)

Feature	MVEMPs (Masseter VEMPs)	CVEMPs (Cervical VEMPs)	OVEMPs (Ocular VEMPs)
Afferent receptor origin	Saccular macula (predominant); possibly utricular contribution	Saccular macula (predominant)	Utricular macula (predominant) minor saccular contribution
Reflex arc / pathway	Vestibulotrigeminal (otolith → vestibular nuclei → trigeminal motor nucleus → masseter)	Sacculo-collic (otolith → vestibular nuclei → spinal accessory nucleus → SCM)	Utriculo-ocular (otolith → vestibular nuclei → oculomotor nuclei → extraocular muscles)
Recording site / electrode placement	Inferior third of masseter, reference at zygomatic arch or forehead (zygomatic montage)	Over mid-SCM belly, reference at sternoclavicular notch or mastoid	Infra-orbital skin below eye (active), reference below it or at chin/ forehead
Activation required	Moderate jaw clench	Active head rotation or neck flexion to contract SCM	Upward gaze to tonically activate inferior oblique
Morphology	Biphasic: P1 (≈10–12 ms), N1 (≈20–22 ms)	Biphasic: P13–N23	Biphasic: N10–P15
Typical amplitude (μV)	80–150 μV (depends on EMG normalisation)	100–200 μV	5–15 μV
Stimulus modality	Air-conducted (click/tone/ chirp) or bone-conducted vibration	Air-conducted or bone-conducted	Primarily bone-conducted vibration; AC also possible
Optimal frequency	500 Hz NB CE-chirp or tone-burst	500 Hz tone-burst	500 Hz tone-burst
Latency range	P1 9–13 ms; N1 17–24 ms	P13–N23 ms	N10–P15 ms
Dominant nerve pathways	Inferior vestibular → trigeminal motor	Inferior vestibular → spinal accessory	Superior vestibular → oculomotor
Polarity relative to stimulus	Inhibitory	Inhibitory	Excitatory
Functional meaning	Reflects vestibulotrigeminal reflex integrity to assess saccular and inferior vestibular nerve function	Reflects sacculo-collic reflex; used to assess saccular and inferior vestibular nerve function	Reflects utriculo-ocular reflex; used for utricular and superior vestibular nerve assessment
Clinical utilities	MS brainstem lesions, vestibular neuritis, Ménière's, trigeminal brainstem disorders, vestibular schwannoma	Inferior vestibular neuritis, Ménière's disease, vestibular schwannoma, inferior vestibular nerve lesions	Superior vestibular neuritis, utricular dysfunction, vestibular schwannoma
Advantages	Alternative to CVEMPs/ OVEMPs when neck or ocular activation limited; tests vestibulotrigeminal pathway	Well-established normative data; robust response amplitude	Sensitive to superior vestibular nerve disorders; good topographical specificity
Limitations	Requires controlled masseter contraction; less standardised; smaller body of evidence	Sensitive to neck fatigue and posture; can be absent in elderly	Low amplitude, higher noise, strong dependence on gaze angle; can be absent in elderly

Feature	MVEMPs (Masseter VEMPs)	CVEMPs (Cervical VEMPs)	OVEMPs (Ocular VEMPs)
Response rate (healthy adults)	~95 % with CE-chirp; 80–85 % with click	~100 % in young adults	85–95 % depending on technique
Clinical maturity	Emerging / under standardisation	Mature, widely validated	Mature, but technique-dependent

Table 5. Comparative characteristics of masseter (MVEMPs), cervical (CVEMPs), and ocular (OVEMPs) vestibular-evoked myogenic potentials.

Clinical applications of the MVEMPs

The technical advances in elicitation and detection of MVEMPs paralleled the accumulation of clinical evidence. The presence of MVEMPs abnormalities has been reported in disorders affecting the vestibulotrigeminal pathway, including multiple sclerosis (Magnano et al. 2014), Parkinson's disease (De Natale et al. 2015), REM sleep behaviour disorders (De Natale et al. 2018), vestibular migraine (Sreedharan and Sinha 2024), Ménière's disease (Behmen et al. 2024), and VN (Comacchio et al. 2025). Comparative studies demonstrated that MVEMPs may remain detectable when CVEMPs are absent in patients with conductive hearing loss, supporting the use of bone-conducted vibration (Kumar et al. 2024). Moreover, the amplitude of the MVEMPs shows a linear dependence on pre-activation EMG, necessitating normalization procedures to control for muscle recruitment (Ramesh and Thirunavukkarasu 2024, Romero et al. 2022).

MVEMPs abnormalities have been observed in patients with multiple sclerosis, often revealing subclinical pontomedullary dysfunction not detected on magnetic resonance imaging or other types of VEMPs (Sangu Srinivasan et al. 2023). Magnano et al. (Magnano et al. 2016, Magnano et al. 2014) reported brainstem abnormality in 82.2% of patients using MVEMPs, 84.4% using brainstem auditory-evoked potentials, 77.8% using magnetic resonance imaging, and 40% using clinical examination. The MVEMPs usually show reduced amplitudes and prolonged latencies (Magnano et al. 2014). MVEMPs have been applied in the study of Parkinson's disease, showing an alteration rate in 66.7% for MVEMPs. Furthermore, they reported a significant reduction in wave amplitude in late phases of Parkinson's disease (De Natale et al. 2014).

MVEMPs have been applied to assess peripheral vestibular system diseases. Patients affected by Ménière's disease and recurrent vestibulopathy, MVEMPs abnormality rates appear comparable or slightly higher than CVEMPs, implying distinct yet complementary diagnostic information (Behmen et al. 2024). In auditory neuropathy, dissociation between preserved MVEMPs and absent CVEMPs responses suggests differential resilience of vestibulotrigeminal circuits (Kılınç et al. 2023).

Recently, some research groups have investigated the role of MVEMPs in differential diagnosis and tracking of recovery in VN (Comacchio et al. 2025, Rajesh and Neupane 2024). VN is characterised by acute spontaneous vertigo without hearing loss and without central neurological signs. The absence of MVEMPs, with partial impairment of CVEMPs and posterior semicircular canal (PSC) function, demonstrates the involvement of the vestibulotrigeminal pathway. Rajesh and Neupane (Rajesh and Neupane 2024) with superoinferior VN exhibited concordant results between CVEMPs and MVEMPs. Furthermore, a study from our research group (Comacchio et al. 2025) demonstrated that MVEMPs show greater robustness than CVEMPs in superior vestibular nerve lesions with partial saccular involvement. There was full concordance between MVEMPs and CVEMPs in patients with saccular sparing and tricanalar involvement. These discrepancies between MVEMPs and CVEMPs raise fur-

ther questions about the lesion site or even the origin of MVEMPs.

Advantages and Limitations

MVEMPs offer several notable advantages in clinical practice, including the ability to probe vestibulotrigeminal pathways, that are inaccessible through conventional CVEMPs or OVEMPs testing (Nagarajan et al. 2024, Rosengren et al. 2018). They also represent an alternative for saccule analysis when cervical activation is limited, such as in patients with neck immobility. Furthermore, their feasibility using bone-conducted stimulation further expands their diagnostic applicability. Nonetheless, relevant limitations persist: MVEMPs responses depend strongly on the level of masseter contraction (Romero et al. 2022), and variability in electrode montage alters inter-laboratory reproducibility (Thirusangu and Sinha 2022). Moreover, no universal normative data and disorder-specific diagnostic cut-offs are available so far (Nagarajan et al. 2024).

Open debates and future directions

Several aspects of the current literature on MVEMPs remain promising yet not fully consolidated. First, the precise origin of the MVEMPs is still debated: although a saccular source is the most widely accepted, some authors (Kjærsgaard et al. 2025) propose a non-exclusive or mixed otolithic–cochlear contribution. Moreover, the clinical role of MVEMPs in disorders such as Parkinson's disease, multiple sclerosis, Ménière's disease, VN, and vestibular migraine is supported mainly by small studies or case series (Comacchio et al. 2025, Behmen et al. 2024, Rajesh and Neupane 2024 De Natale et al. 2015, Magnano et al. 2014), highlighting the need for extensive prospective investigations.

Future research priorities for MVEMPs include the development of protocols for standardised acquisition and analysis comparable to existing CVEMPs and OVEMPs guidelines (Nagarajan and Sinha 2024). Expanding normative datasets across different age groups and clinical populations remains essential, as does integrating MVEMPs testing with advanced neuroimaging techniques to characterise vestibulotrigeminal pathways and more precisely distinguish peripheral from central lesions (Rosengren et al. 2018). The MVEMPs are a promising tool for assessing the peripheral generator, complementary to CVEMPs but related to a different central pathway. It has also been reported in various studies that MVEMPs is superior to CVEMPs and OVEMPs in identifying brainstem diseases.

Moreover, rigorous evaluation of the prognostic utility of MVEMPs in vestibular rehabilitation and in the monitoring of neurodegenerative conditions (Comacchio et al. 2025, Srinivasan et al. 2023) represents a key direction for future investigation.

Finally, interference from anatomical factors—such as dentition status, dental implants, or masseter hypotrophy—has been documented (Mayil et al. 2018), yet remains insufficiently quantified, representing an active and evolving area of research.

Conclusions

MVEMPs have evolved from an experimental finding into a clinically relevant, non-invasive probe of vestibulotrigeminal pathway. When performed with standardised methodology, it provides complementary diagnostic insights alongside CVEMPs and OVEMPs. The next step for MVEMPs research involves establishing international reference standards and validating its role in specific neurological and vestibular pathologies.

Conflicts of interest: The authors declare no conflicts of interest.

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