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Neuromuscular Ultrasound Assessment of the Facial Nerve in Bell's Palsy: A Narrative Review

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ABSTRACT

Facial palsy presents a diagnostic challenge, with most acute cases classified as idiopathic (Bell's palsy). As a diagnosis of exclusion, it requires careful evaluation to rule out other treatable or serious causes. Conventional imaging modalities such as CT and MRI can identify underlying pathology; however, they are costly and not always readily available. High-resolution ultrasonography (HRUS) has emerged as a practical complementary tool, offering non-invasive, accessible, and radiation-free imaging that enables direct assessment of facial nerve morphology, pathological changes, and compressive lesions. This narrative review is evidence-based while also incorporating practical insights from recent clinical applications. It aims to provide clinicians with an accessible overview of HRUS in Bell's palsy, with emphasis on sonographic techniques, procedural standards, characteristic findings, and their clinical implications for patient diagnosis and management.

KEYWORDS: Bell's palsy, neuromuscular ultrasound, high-resolution ultrasonography, facial nerve.

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INTRODUCTION

Bell's palsy represents the most frequent cause of acute unilateral facial paralysis and is generally attributed to idiopathic inflammation of the facial nerve (cranial nerve VII). Although its precise etiology remains unclear, the prevailing hypothesis suggests that viral reactivation triggers inflammatory edema within the bony facial canal, resulting in nerve compression, ischemia, and subsequent functional impairment ***(1).***

Although many cases of Bell's palsy are self-limiting, predicting recovery outcomes and identifying patients at risk for incomplete restoration of facial muscle function remains a significant clinical challenge, particularly during the early stages of the disease ***(2).*** Diagnosis has traditionally been based on clinical assessment supported by electrodiagnostic studies. However, conventional electrodiagnostic methods have notable limitations: they often fail to localize the lesion or determine the underlying etiology, they may be uncomfortable or painful for patients, and they do not provide morphological information about the facial nerve or adjacent structures ***(3).***

Neuromuscular ultrasound (NMUS) has emerged as a valuable tool in evaluating peripheral nerves, offering dynamic and high-resolution imaging without the use of ionizing radiation ***(4).*** While most cranial nerves are small and deeply located, some, like the facial (VII), vagus (X), spinal accessory (XI), and hypoglossal (XII) nerves, can be visualized with high-resolution ultrasound. The facial nerve (CN VII) is particularly amenable to ultrasound assessment due to its superficial course ***(5).***

This article provides a review of NMUS for the facial nerve, emphasizing scanning techniques, clinical applications, advantages, and limitations.

Principles and Technique of Facial Nerve Ultrasonography

High-resolution ultrasonography (HRUS) has been increasingly applied to the evaluation of the extratemporal segment of the facial nerve in Bell's palsy, particularly the main trunk after its exit from the stylomastoid foramen and during its course within the parotid gland ***(6).*** The technique is inherently operator-dependent and requires detailed knowledge of anatomical landmarks as well as proficiency in sonographic interpretation to ensure accurate identification and measurement ***(7).***

Ultrasonographic measurements of the extratemporal facial nerve have demonstrated strong correlations with clinical grading outcomes ***(8).*** From an anatomical perspective, the extratemporal part (main trunk) divides into two primary branches—the temporofacial and cervicofacial divisions—which further subdivide into terminal branches: temporal, zygomatic, buccal, marginal mandibular, and cervical. These can be visualized within the parotid gland ***(9).***

A. Transducer Selection and Equipment Settings

A high-frequency linear array transducer, typically operating at 15–18 MHz, is essential for the spatial resolution required to delineate the small caliber of the facial nerve against surrounding echogenic tissues. Optimal visualization of the extracranial segment is typically achieved at a scanning depth of 2–3 cm ***(5, 8).***

B. Patient Positioning and Probe Orientation

The preferred patient position is lateral decubitus, with the head supported on a pillow and gently rotated to the contralateral side. This minimizes motion artifacts and provides stable access to the scanning region ***(10).*** The transducer is placed transversely just below the earlobe, anteriorly to the mastoid bone, and parallel to the mandibular ramus, with the marker directed toward the examiner's left. This allows visualization of the nerve either within the parotid gland ***(5).*** and the transducer is placed longitudinally immediately after the nerve emerges from the stylomastoid foramen, where it passes between the mastoid and styloid processes ***(11).*** For accurate measurement, the probe should remain perpendicular to the skin with minimal pressure to prevent deformation ***(10).***

C. Scanning Planes and Visualization

Two principal imaging planes are employed. The longitudinal view (transverse probe orientation) is most effective for following the nerve trunk between the superficial and deep lobes of the parotid gland ***(12).*** The axial view (longitudinal probe orientation), obtained anterior to the mastoid and posterior to the auricle, demonstrates the nerve as it exits the stylomastoid foramen—the most proximal segment accessible to ultrasound ***(11).*** At this site, the posterior auricular artery (PAA) crosses the facial nerve, serving as a critical landmark for facial nerve visualization and ultrasound-guided interventions ***(13).*** Doppler imaging is recommended to identify the PAA reliably. Sonographically, the facial nerve typically appears as a linear structure that is hypoechoic and surrounded by a perineural hyperechoic sheath, most often located at a depth of 1.5–2 cm ***(11).*** Cross-sectional views are more challenging due to the nerve's small caliber ***(14).***

In the longitudinal plane, the facial nerve is visualized as a thin, tubular structure with a hypoechoic center and a hyperechoic rim coursing through the relatively homogeneous parotid gland. It can be assessed for size, echogenicity, and vascularity. Diameter is measured at the thickest point, including the outer rim, with the largest of multiple readings selected. Changes in echogenicity may reflect pathology: chronic lesions often display hyperechoic changes due to fibrosis or adhesions, whereas acute edema may obscure the borders ***(5, 8 and 10).***

The nerve can also be traced at the posterior region, anterior to the mastoid tip, and below the ear lobule, where it emerges from the stylomastoid foramen and enters the parotid gland before dividing into five branches. Color Doppler can help identify the facial artery, which lies deep to the nerve. Distal branches may be followed as the trunk bifurcates into upper (temporo-zygomatic) and lower (Cervico-mandibular) divisions, although terminal branches are usually too fine for reliable visualization and are inferred by surrounding landmarks ***(15).***

D. Identification of the Nerve Trunk and Branches

The parotid duct represents the structure most frequently mistaken for the facial nerve. However, the standard scanning window avoids this region, as the duct emerges from the anterior border of the parotid gland toward the oral cavity. Confusion is most likely with the buccal branches beneath the zygomatic bone. Distinction relies on the fact that nerves are non-compressible, whereas ducts may collapse under pressure and exhibit Doppler flow. Dynamic maneuvers, such as instructing the patient to smile or frown, can further confirm nerve identity, as the nerve moves while the duct remains stationary ***(15).***

Additional structures, such as the retromandibular vein and anterior cervical artery, also course near the nerve but can be easily differentiated by color Doppler, with veins collapsing under pressure and arteries demonstrating pulsations. The main facial artery and vein accompany the mandibular branch near the inferior mandibular border but rarely cause diagnostic confusion ***(Baek et al., 2020) (16).*** Distal branches may occasionally be traced by following the bifurcation of the main trunk, though visualization of terminal branches is limited ***(15).***

Eventually, there are both measurement strategies; many authors, including **Tawfik et al. (2015), Baek et al. (2020), and Di Pietro et al. (2024),** recommend assessing the main trunk within the parotid gland before its branching (Figure 1). Conversely, **Abdulsalam et al. (2024) (16)** propose measurement at the most proximal and largest portion, immediately after emergence from the stylomastoid foramen (Figure 2). This proximal site minimizes the risk of including parotid divisions and is considered both the most accurate representation of the main trunk and the segment most relevant to potential entrapment.

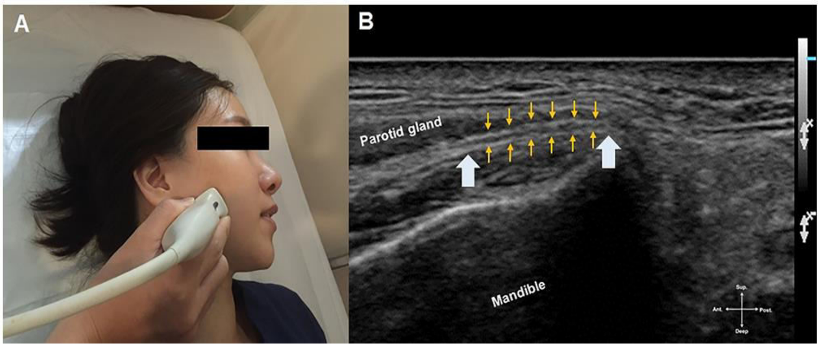

Figure 1. (A) The probe is placed below the ear lobule along the longitudinal course of the facial nerve (longitudinal view) within the parotid gland. (B) The facial nerve appears as a thin tubular structure surrounded by the sheath inside the parotid gland. Adopted from: *Baek et al., 2020*

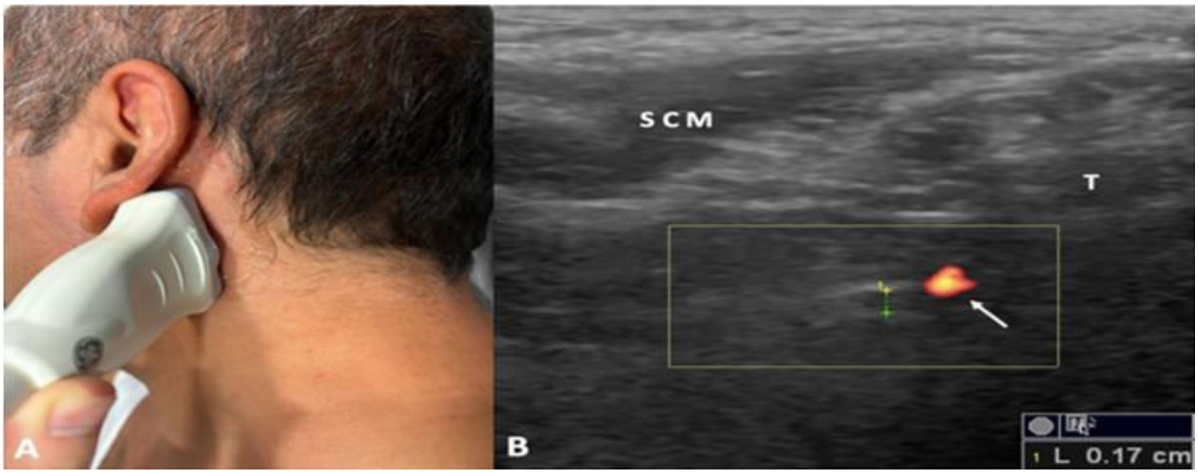

Fig.2. Patient and probe positioning during the ultrasound examination (A). Measurement of the facial nerve main trunk (longitudinal view) as it exits through the stylomastoid foramina (B). T: temporal bone, SCM: sternocleidomastoid muscle, arrow: posterior auricular artery, adopted from *Abdulsalam et al. (2024).*

Clinical Utility of Neuromuscular Ultrasound in Bell's Palsy

Neuromuscular ultrasound (NMUS) has emerged as a valuable adjunct in the diagnosis, prognosis, and therapeutic interventions for Bell's palsy management. It enables direct structural assessment of the facial nerve, allowing visualization of swelling, echotexture alterations, and secondary muscle changes. Its non-invasive, rapid, and repeatable nature makes it particularly suitable for use in both the acute and chronic phases of the disease ***(17).***

Nerve Enlargement

One of the most consistent sonographic findings in Bell's palsy is enlargement of the affected nerve, most often detected as an increase in diameter rather than cross-sectional area, due to the technical challenges of axial imaging in the parotid region as mentioned by ***Lo et al., (2010)and ; Tawfik et al., (2015).*** Enlargement may be observed during the early phase, even before clinical or electrophysiological abnormalities fully manifest. This finding is attributed to perineural edema and inflammation, frequently related to entrapment within the bony facial canal ***(7).*** Serial measurements can also be used to monitor response to corticosteroid therapy, physical rehabilitation, or surgical intervention ***(18).***

Hypo-echogenicity and Loss of Fascicular Pattern,

Under normal conditions, the facial nerve appears as a thin, tubular structure with a hypoechoic center and a hyperechoic rim, displaying a linear fascicular pattern relative to surrounding tissue. In contrast, affected nerves often demonstrate swelling, diffuse hypoechogenicity, and a reduction or loss of internal fascicular definition. The outer hyperechoic border may appear blurred or indistinct, particularly in acute inflammatory states as reported by **Li et al., (2015), Khazaei et al., (2022) (19) and Abdulsalam et al., (2024) (16).**

Vascularity Changes (Power Doppler);

Color or power Doppler imaging may reveal increased vascular flow surrounding the facial nerve, a feature that can suggest active inflammation or neovascularization in early stages. Although not consistently reported across all studies, vascularity assessment can complement other sonographic findings, particularly when evaluating atypical cases or monitoring treatment response ***(18).***

Muscle Changes

Beyond nerve assessment, high-resolution ultrasound can be applied to evaluate facial muscles for evidence of denervation atrophy, particularly in chronic or severe cases. Muscle degeneration most commonly affects the zygomaticus major, zygomaticus minor, and levator labii superioris, which elevate the oral commissure and are among the first to exhibit volume loss. Additional sonographic findings may include shrinkage, hyperechoic changes, and fascial adhesions ***(20).*** Such assessment can inform prognosis, guide rehabilitative strategies, and support decisions regarding interventions such as surgical repair or botulinum toxin injection

Dynamic ultrasound has also been employed in selected cases to assess aberrant reinnervation. Using M-mode, abnormal early synkinesis activity can be demonstrated—for example, when the probe is positioned on the orbicularis oris muscle and the patient is asked to blink the ipsilateral eye, muscle contraction can be observed, which may be earlier than clinically apparent, indicating misdirected nerve regeneration ***(10; 18).*** This advantage is particularly valuable for monitoring progress or recovery. Unlike MRI and CT, which are limited by static imaging planes, ultrasound affords dynamic flexibility, allowing real-time visualization aligned with the orientation of the facial muscles ***(21).***

Bell's palsy Severity Grading and Prognosis:

Recent evidence highlights the role of ultrasound in predicting outcomes in Bell's palsy by correlating facial nerve diameter with clinical grading scores and electrodiagnostic studies. Ultrasonographic measurements have shown significant associations with both clinical and electrophysiological findings, underscoring its value as a complementary technique for assessing disease severity and prognosis ***(8, 16 and (22).***

Lo et al. (2010) demonstrated that NMUS-derived nerve diameter was superior to electrodiagnostic studies (EDX) in predicting recovery outcomes. Similarly, **Di Pietro et al. (2024)** confirmed that HRUS could detect acute-phase nerve enlargement, although its predictive value for incomplete recovery was somewhat lower than that of EDX.

Gupta et al. (2013) further emphasized the prognostic relevance of ultrasound, showing that normal sonographic findings of the affected nerve had a 100% positive predictive value for complete recovery at three months. This accuracy exceeded that of nerve conduction studies (72–80%) and blink reflex testing (90%). Conversely, abnormal ultrasound measurements carried a 77% negative predictive value for persistent dysfunction (House-Brackmann grade II or worse), again outperforming nerve conduction (25–35%) and blink reflex (33%).

Taken together, these findings support the integration of NMUS with EDX, as the two methods provide complementary information: NMUS offers morphological assessment, while EDX provides functional data. Their combined use improves the accuracy of severity grading and prognostication. Importantly, NMUS is particularly useful in settings where EDX is unavailable, delayed, or inconclusive ***(22).***

Differentiating Bell's Palsy from Other Causes of Lower Facial Palsy

Although Bell's palsy is idiopathic, ultrasound can raise suspicion for alternative potential causes of facial nerve dysfunction. For example, intra-parotid facial nerve schwannomas, or neuromas, may appear as focal hypoechoic swellings along the course of the nerve ***(23),(24).***

Similarly, parotid tumors can displace or infiltrate facial nerve branches, sometimes presenting with facial paralysis. In such cases, ultrasonographic detection of a parotid mass or adenoma is highly suggestive ***(25), (26).*** In addition to diagnosis, ultrasound may provide information on the relationship between parotid tumors and the facial nerve, aiding surgical planning and potentially reducing the risk of iatrogenic nerve injury—an outcome with major implications for patients' quality of life ***(27).***

NMUS also proves useful in the evaluation of traumatic injuries, such as those occurring after parotidectomy, where it can demonstrate nerve thinning or discontinuity. While these features can often be depicted with greater detail on MRI, NMUS offers valuable preliminary information and is particularly advantageous when MRI is contraindicated or unavailable ***(28).***

Imaging and US-guided injections of the facial nerve and muscles

Beyond its diagnostic applications, NMUS also provides therapeutic value by guiding targeted interventions. Accurate localization of the facial nerve trunk facilitates precise perineural corticosteroid injections, providing an alternative to systemic therapy, which is often limited by side effects. Under real-time guidance, a 22–27 G needle can be advanced using a direct in-plane approach to deliver corticosteroids perineurally. Particular caution is required to avoid injury to the posterior auricular artery (PAA). It is advisable to utilize non-particulate agents like dexamethasone, as they carry a lower risk of neurotoxicity ***(29).***

Botulinum toxin (BoNT) injections have also gained prominence in managing Bell's palsy. They may be applied to the normal side to improve symmetry or to the diseased side to reduce synkinesis, ultimately enhancing both function and aesthetics ***(30).*** While blind injection remains common practice, it carries risks including diplopia, ptosis, lagophthalmos, speech disturbances, cosmetic asymmetry, and unintended muscle paralysis ***(31).*** Ultrasound guidance improves precision, reduces complications, and increases safety, making it the preferred technique for BoNT administration ***(29).***

Limitations and Challenges of NMUS assessment of the facial nerve in Bell's palsy

Despite its advantages, neuromuscular ultrasound (NMUS) faces several limitations that may restrict its routine application.

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- **Operator Dependency;**

NMUS is highly dependent on examiner expertise. Accurate assessment requires detailed anatomical knowledge and skill in nerve tracing, particularly in the parotid region, where the facial nerve is embedded in isoechoic glandular tissue. Variability in probe placement, angle, and measurement technique can influence results, highlighting the importance of standardization and training.

Limited Visualization of Intra-temporal Segments

Because ultrasound waves cannot penetrate bone, intra-temporal portions of the facial nerve, including the labyrinthine and tympanic segments, remain inaccessible. Consequently, NMUS is limited to the extracranial portion of the nerve, while pathology extending from the brainstem to the stylomastoid foramen requires alternative imaging such as MRI ***(20).***

Lack of Standardized Reference Values

Currently, there is no universally accepted reference range for normal facial nerve diameter or side-to-side asymmetry. Some studies have suggested cutoff values (e.g., ≥0.9 mm) to distinguish affected patients from healthy controls ***(5),*** but these thresholds vary across studies and populations, limiting their generalizability.

CONCLUSION;

Neuromuscular ultrasound is a rapid, non-invasive, and cost-effective tool for evaluating the facial nerve and other accessible cranial nerves. In Bell’s palsy, it can confirm the presence of an inflamed facial nerve, rule out other potential pathologies, and contribute to both diagnostic and prognostic assessment. Beyond imaging, NMUS also plays a therapeutic role by guiding perineural corticosteroid injections with precision, thereby reducing systemic exposure and potential complications. The ability to localize the exact injection site further enhances its clinical utility. While NMUS cannot replace MRI for intra-temporal or central lesions, its accessibility, safety, and repeatability make it a valuable complementary modality in the comprehensive management of Bell’s palsy.

Conflict of Interest

The authors declare that there are no conflicts of interest regarding the publication of this paper.

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