Current State of Intraoperative Neuromonitoring of the Facial Nerve during Skull Base Surgery: A Scoping Review

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Introduction

The facial nerve (cranial nerve VII) is responsible for motor control of the muscles of facial expression, stapedius muscle, taste of the anterior two-thirds of the tongue, parasympathetic control of multiple glands, and more. Arising from the pons, the facial nerve courses through the cerebellopontine angle (CPA) before entering the internal auditory canal, then through the facial canal, and then taking multiple courses to the final locations of innervation. This complex trajectory places the facial nerve in close proximity to many potential pathologies and surgical corridors. Injury to the facial nerve results in significant morbidity to the patient, and therefore many intraoperative neuromonitoring (IONM) methods have been developed for identification, preservation, and prognostication for the function of the facial nerve during skull base surgery. Relying on the principles of electromyography (EMG), many methods of stimulation and recording have been developed to best protect the facial nerve.

Due to the breadth of pathologies and surgical approaches that necessitate appropriate facial nerve identification and monitoring, researchers and clinicians have utilized numerous methodologies. These include both free running and evoked facial nerve EMG (FEMG), facial corticobulbar muscle evoked potentials (FCoMEP) , abnormal muscle response and the lateral spread response (AMR) , the blink reflex, and others (**Fig 1**). This wide array of techniques can be daunting to understand and therefore the objective of this paper is to provide a scoping review for the skull base surgeon of the most used methodologies, promising but less discussed methods, as well as the standard usage of each method across pathology and approach.

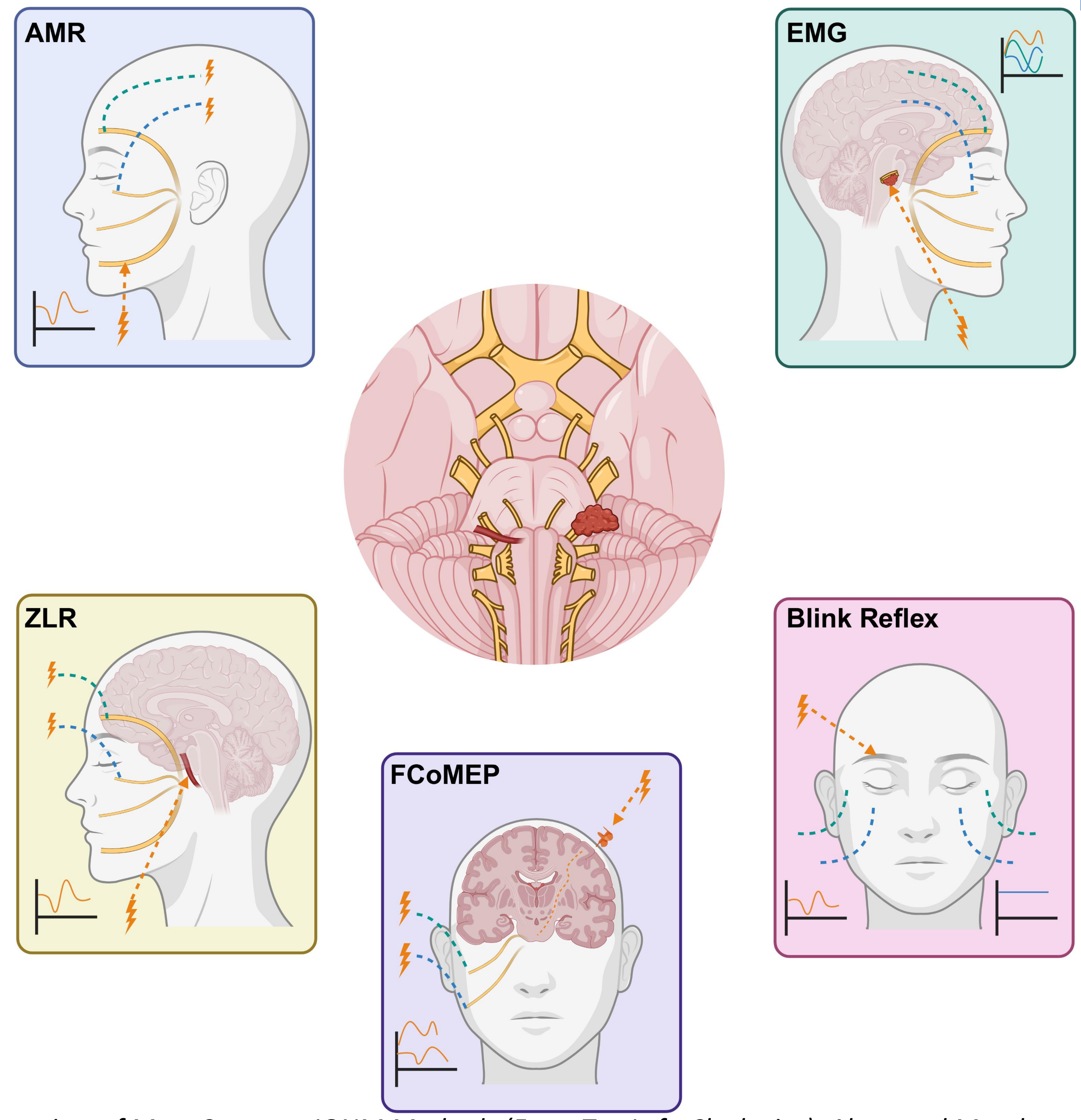

Figure 1: *Overview of Most Common IONM Methods (From Top Left, Clockwise): Abnormal Muscle Response/Lateral Spread Response (AMR), Free/Stimulated EMG (Orange Represents Evoked EMG), Blink Reflex, Facial Corticobulbar Muscle Evoked Potentials, ZL-Response (ZLR). Dashed Orange line represents stimulation electrode, Dashed Blue and Green lines represent signal electrodes.*

Methods

This review was performed in accordance with the Preferred Reporting Items for Systematic reviews and Meta-Analyses extension for Scoping Reviews (PRIMSA-ScR) checklist. The comprehensive search strategy was created in collaboration with our research librarian (SJK), to identify articles related to intraoperative neuromonitoring of the facial nerve and the skull base. These terms were searched on the PubMed/MEDLINE database on July 1, 2024, and all resulting articles had their metadata retrieved. No date restrictions were applied, and only English articles were reviewed. Covidence Extraction software (Veritas Health Innovation, Melbourne, Australia) was used. After default duplication screening was conducted, 2776 citations were eligible for screening.

Results

The initial abstract/title screen had 2,776 studies with 550 meeting criteria for full text screening. After a comprehensive full text screening, 174 studies were included for analysis. The most commonly mentioned method FEMG which was directly described in 80.50% (140/174) of studies. FCoMEPs were described in 25.86% (45/174) of studies. AMR and its most common form of lateral spread response (LSR) were described in 21.26% (27/174) of studies. The blink reflex was described in 4.60% (8/174) of studies (**Fig. 2A**). A total of 25 distinct modalities were discussed. The studies had an average sample size of 102 ± 48 patients (range 10-150). In these studies, other cranial nerves were also monitored simultaneously: the vestibulocochlear nerve monitored in 16.67% (29/174), the trigeminal nerve in 8.05% (14/174), and the spinal accessory nerve 1.15% (2/174) of the papers (**Fig. 2B**). 77.01% (134/174) of papers monitored the facial nerve in isolation. The most commonly discussed pathology was vestibular schwannoma (67.81%, 118/179) studies, followed by hemifacial spasm (25.39%, 44/174), meningioma (17.82%, 31/174), and epidermoid cyst (7.47%, 13/174) (**Fig. 2C**). Specific pathology was not stated in 1.72% (3/174) of articles. Various surgical approaches were discussed in these studies with the retromastoid /suboccipital approaches being the most common (60.30%, 105/174) followed by translabryinthine (26.44%, 46/174), and middle cranial fossa (12.07%, 21/174)(**Fig. 2D**). Exact approaches were not stated in 28.74% (50/174) of articles, and multiple articles reported patient positioning (e.g. park bench, prone, lateral debicutis, etc.) in place of surgical approach.

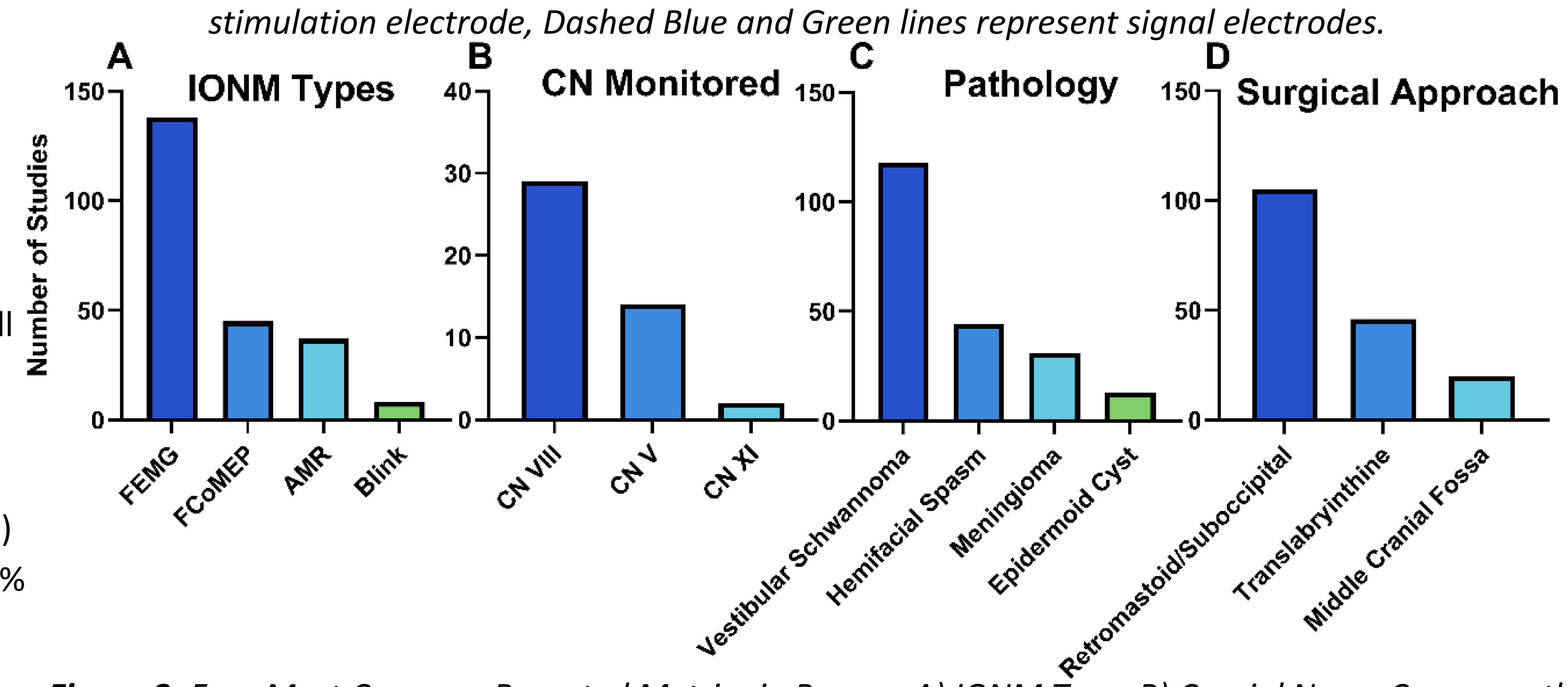

Figure 2*: Four Most Common Reported Metrics in Papers: A) IONM Type, B) Cranial Nerve Concurrently Monitored, C) Pathology Approached, D) Surgical Approach*

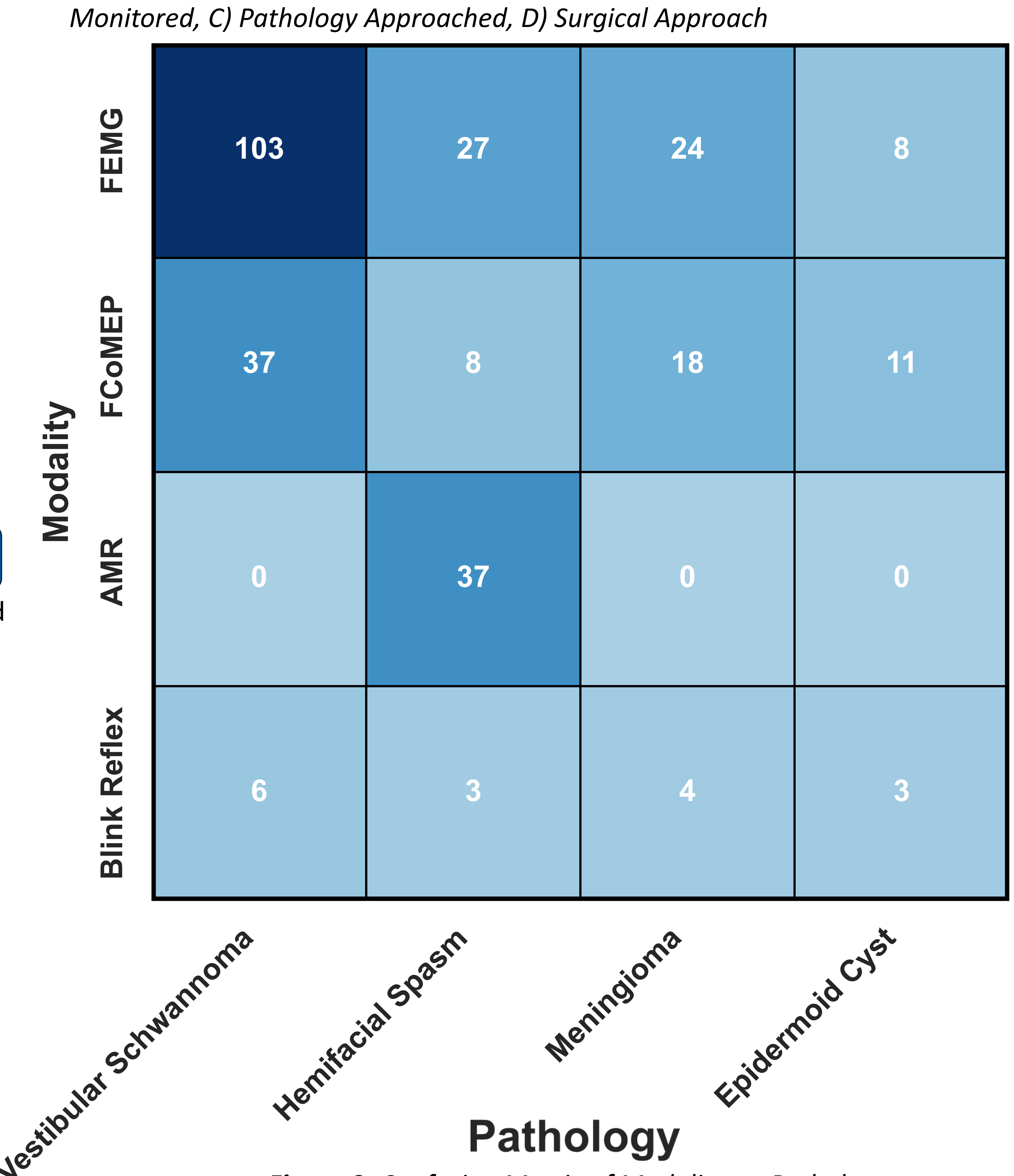

Figure 3: *Confusion Matrix of Modality vs. Pathology*

Conclusions

Intraoperative neuromonitoring (IONM) of the facial nerve during skull base surgery is a diverse field which is integral to ensuring positive patient outcomes. This scoping review highlights the extensive range of methodologies available to the skull base surgeon and focuses on both the most established techniques such as free running and evoked facial nerve EMG, facial corticobulbar motor evoked potentials, and abnormal muscle response to less frequently discussed modalities that show promise such as the blink reflex and ZL-response. Each method carries unique advantages and limitations, and their applicability is highly dependent on the pathology, surgical approach, and team workflow. The continued evolution of IONM techniques underscores the need for collaboration among skull base surgeons, neurophysiologists, anesthesiologists, neuroscientists, and engineers to refine, standardize, and share protocols to maximize patient safety in complex operations.

Acknowledgements

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