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Case Study

Neuromuscular Evaluation of the Laryngeal disorders Using Electromyography

Shradha Saindani[1]* and Sachin Gandhi[2]

[1]*Junior Consultant at Deenanath Mangeshkar Hospital, Pune, India*

[2]*Consultant at Deenanath Mangeshkar Hospital, Pune, India*

***Corresponding Author:** Shradha Saindani, Junior Consultant at Deenanath Mangeshkar Hospital, Pune, India.

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Abstract

Laryngeal electromyography (LEMG) demonstrates high diagnostic sensitivity and prognostic reliability in evaluating laryngeal neuromuscular disorders. We conducted a prospective case series of 37 patients presenting with voice and swallowing disorders to assess the diagnostic and therapeutic impact of LEMG. The study included vocal cord immobility (n = 15), presbyphonia (n = 7), spasmodic dysphonia (n = 5), puberphonia (n = 5), and dysphagia (n = 5). LEMG altered clinical management in 70.2% of cases by differentiating neurogenic from mechanical etiologies, predicting neural recovery, and guiding targeted interventions such as medialization or LEMG-guided botulinum toxin injection. Significant improvement in Voice Handicap Index scores was observed post-intervention ($p < 0.001$). Dysphagia patients demonstrated statistically significant improvement following cricopharyngeal botulinum injection ($p = 0.012$). This case series highlights the critical role of LEMG in refining diagnosis, guiding precision-based therapy, and optimizing patient-specific outcomes in contemporary laryngology practice.

Keywords: Laryngeal Electromyography; Vocal Fold Paralysis; Spasmodic Dysphonia; Presbyphonia, Puberphonia; Dysphagia; Cricopharyngeus Dysfunction; Botulinum Toxin; Neuromuscular Disorders; Voice Disorders

Introduction

Laryngeal Electromyography (LEMG) is an established neurophysiological investigation that has gained increasing importance in contemporary otorhinolaryngology for the evaluation of laryngeal neuromuscular function. The larynx is a highly specialized organ requiring precise neural control for phonation, respiration, and airway protection. Any disruption in the neural input to intrinsic laryngeal muscles can result in significant voice, swallowing, and airway compromise. Clinical assessment and endoscopic visualization alone often fail to accurately determine the underlying etiology of laryngeal movement disorders, particularly in cases of vocal fold immobility.

LEMG provides direct, objective assessment of motor unit activity within individual intrinsic laryngeal muscles by recording electrical potentials at rest and during voluntary tasks. This allows differentiation between neurogenic paralysis, synkinesis, and mechanical fixation—an essential distinction for appropriate treatment planning. Moreover, LEMG enables evaluation of the severity and chronicity of nerve injury, offering prognostic information regarding spontaneous recovery. Early identification of irreversible denervation helps clinicians determine the optimal timing for surgical interventions such as medialization thyroplasty or laryngeal reinnervation.

Beyond vocal fold paralysis, the clinical applications of LEMG have expanded to include assessment of superior laryngeal nerve dysfunction, spasmodic dysphonia, tremor, and functional voice disorders. Emerging uses in dysphagia evaluation and dynamic assessment during phonation and swallowing have further broadened its scope. As an adjunct to endoscopic and imaging modalities, LEMG enhances diagnostic accuracy and facilitates individualized, evidence-based management. With growing expertise and technological advancements, LEMG continues to evolve as an indispensable tool in comprehensive ENT practice.

Materials and Methods

Study design

We conducted a prospective observational case series between January 2023 and December 2024 at a tertiary ENT referral center. Institutional ethics approval was obtained. Written informed consent was secured from all patients.

Study population

A total of 37 patients presenting with voice or swallowing disorders underwent LEMG.

Inclusion criteria

- Age > 15 years
- Persistent dysphonia (>3 weeks)
- Suspected vocal fold immobility
- Suspected laryngeal nerve injury
- Suspected cricopharyngeal dysfunction
- Candidates for LEMG-guided botulinum toxin injection

Exclusion criteria

- Acute laryngeal infection
- Intrinsic laryngeal malignancy
- Prior reinnervation surgery
- Coagulopathy
- Refusal for needle examination

LEMG equipment and technique: (Image A)

We performed all studies using the Natus Nicolet Viking EDX EMG System (Natus Medical Inc., USA).

Needle electrodes

Monopolar concentric needle electrode (27G, 37 mm).

Muscles evaluated

- Thyroarytenoid (TA)
- Cricothyroid (CT)
- Posterior cricoarytenoid (PCA)
- Cricopharyngeus (CP)

Parameters assessed

- Insertional activity
- Spontaneous activity (fibrillations, positive sharp waves)
- Motor unit potential amplitude and duration
- Recruitment pattern
- Interference pattern
- Task-specific activation

Dynamic assessment was performed during sustained phonation, pitch glide, sniff maneuver, and dry swallow.

Statistical analysis

We analyzed data using SPSS Version 26.0.

- Mean ± SD calculated for age
- Gender distribution expressed as percentage
- Paired t-test for pre- and post-treatment improvement
- Chi-square for categorical comparison
- $p < 0.05$ considered statistically significant

Results

Demographics

- Total patients: 37
- Mean age: 44.8 ± 16.2 years
- Females: 21 (56.7%)
- Males: 16 (43.3%)

Distribution by diagnosis

Condition	Number	Percentage
Vocal Cord Immobility	15	40.5%
Presbyphonia	7	18.9%
Spasmodic Dysphonia	5	13.5%
Puberphonia	5	13.5%
Dysphagia	5	13.5%

Table 1

Impact on management

LEMG altered clinical management in 26 of 37 patients (70.2%).

Voice outcomes

Mean Voice Handicap Index improved significantly:

- Pre-treatment: 68.4 ± 10.2
- Post-treatment: 29.6 ± 8.4
- $p < 0.001$

Dysphagia outcomes

Swallowing scores improved significantly following LEMG-guided botulinum injection:

$p = 0.012$

Images A: Laryngeal Electromyography machine.

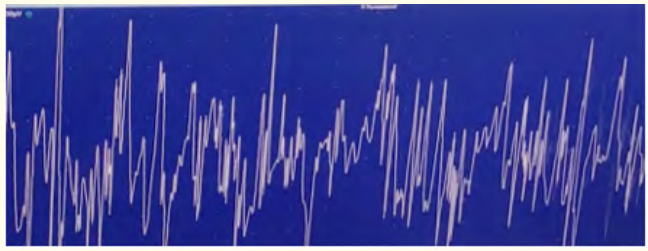

Image B: Normal waveform with High Amplitude waveform.

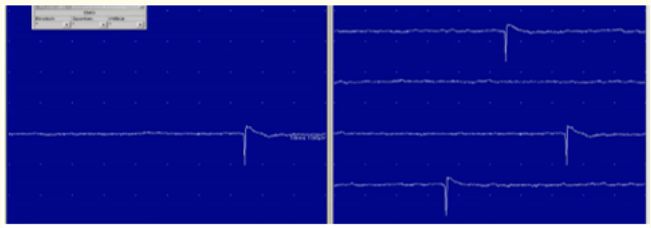

Image C: Positive sharp waves – downward deflection of the electric potentials (indicates on going denervation potentials in the target muscle).

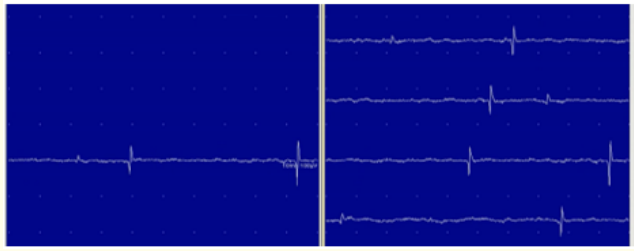

Image D: Fibrillations (indicates on going denervation potentials in the target muscle).

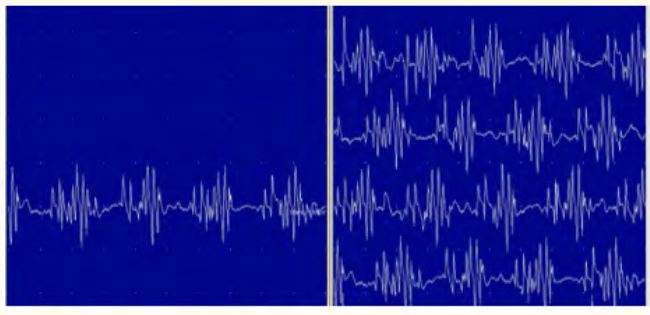

Image E: Polyphasic waves (indicates on going regeneration).

Clinical applications of laryngeal electromyography

Laryngeal electromyography (LEMG) was performed in a cohort of patients presenting with diverse voice and swallowing disorders to evaluate neuromuscular function, establish etiology, and guide targeted management. The clinical utility of LEMG was evident across multiple conditions, significantly influencing treatment decisions.

Vocal cord immobility (15 patients)

Among patients with vocal cord immobility, LEMG played a decisive role in differentiating neurogenic from mechanical causes. Six patients demonstrated normal motor unit potentials with preserved recruitment, consistent with cricoarytenoid joint fixation, thereby avoiding unnecessary neural interventions and directing management toward joint mobilization or arytenoidectomy. Four patients showed reduced recruitment with preserved motor unit morphology, suggestive of vocal fold paresis; these patients were managed conservatively with voice therapy and close follow-up. Only five patients exhibited established denervation characterized by fibrillation potentials, positive sharp waves, and absent voluntary motor unit activity (Image C,D,E). In these cases, early definitive interventions such as medialization procedures or reinnervation planning were undertaken, thereby optimizing functional outcomes. Thus, LEMG directly altered the treatment pathway by preventing overtreatment and facilitating timely surgical decision-making.

Spasmodic dysphonia (5 patients)

In patients with spasmodic dysphonia, LEMG assessment focused on task-specific hyperactivity, abnormal recruitment patterns, increased motor unit firing rates, and involuntary bursts during phonation (Image B). Differentiation between adductor and abductor types was achieved, enabling precise muscle selection and dosage planning for botulinum toxin therapy.

Presbyphonia (7 patients)

LEMG in presbyphonia revealed reduced motor unit recruitment, low-amplitude potentials, and evidence of age-related neuromuscular atrophy without active denervation. These findings supported conservative management with voice therapy and vocal fold augmentation rather than surgical reinnervation.

Puberphonia (5 patients)

Patients with puberphonia demonstrated normal insertional activity and motor unit morphology, confirming the absence of neurogenic pathology. LEMG findings reinforced the diagnosis of a functional voice disorder, guiding treatment toward behavioral voice therapy and, in selected cases, adjunctive procedures such as injection laryngoplasty.

Dysphagia (5 patients)

In dysphagia patients, LEMG was used to assess suprahyoid and cricopharyngeus muscle activity. Abnormal resting hypertonicity and impaired relaxation of the cricopharyngeus muscle were identified in selected cases. This objective assessment facilitated targeted botulinum toxin injection into the cricopharyngeus muscle, resulting in symptomatic improvement and avoidance of more invasive surgical options.

Overall, LEMG proved to be a critical tool in refining diagnosis, individualizing treatment, and improving clinical outcomes. Three patients in this series underwent LEMG-guided botulinum toxin injections, highlighting its role in precision-based, minimally invasive therapeutic interventions in ENT practice.

Clinical Condition	No. of Patients	LEMG Parameters Assessed	Key LEMG Findings	Impact on Treatment Plan
Vocal Cord Immobility	15	Insertional activity Spontaneous activity (fibrillations, positive sharp waves) Motor unit potential (MUP) morphology Recruitment pattern Volitional activity	6 patients: Normal MUPs and recruitment → Cricoarytenoid joint fixation 4 patients: Reduced recruitment with preserved MUPs → Vocal cord paresis 5 patients: Fibrillations, positive sharp waves, absent/poor recruitment → Established denervation	Avoided unnecessary medialization in joint fixation Conservative management and voice therapy for paresis Early definitive intervention (medialization/reinnervation) for denervation

Spasmodic Dysphonia	5	Task-specific muscle activity Motor unit firing rate Recruitment during phonation Involuntary bursts	Hyperactivity of involved intrinsic laryngeal muscles Abnormal, excessive firing during speech tasks Differentiation between adductor and abductor patterns	Accurate diagnosis Selection of target muscles Planning of botulinum toxin injection
Presbyphonia	7	MUP amplitude and duration Recruitment pattern Evidence of denervation	Low-amplitude MUPs Reduced recruitment No active denervation	Confirmed age-related neuromuscular atrophy Voice therapy and vocal fold augmentation preferred
Puberphonia	5	Insertional activity MUP morphology Recruitment	Normal insertional activity Normal MUPs and recruitment	Excluded neurogenic cause Reinforced functional diagnosis Managed with behavioral voice therapy
Dysphagia	5	Cricopharyngeus muscle resting activity Muscle relaxation during swallowing Recruitment pattern	Increased resting tone of cricopharyngeus Incomplete or absent relaxation during swallow	Targeted LEMG-guided botulinum toxin injection into cricopharyngeus Avoided invasive surgical myotomy
LEMG-guided Botox Injection	3	Precise muscle localization Real-time motor unit confirmation		

Table 2: Clinical Applications and LEMG Findings in Patients Undergoing Laryngeal Electromyography.

Discussion

Laryngeal electromyography (LEMG) has emerged as a pivotal diagnostic and decision-making tool in the evaluation of laryngeal neuromuscular disorders. In the present series, LEMG significantly influenced diagnosis and treatment across a spectrum of voice and swallowing disorders, emphasizing its role beyond a purely investigative modality. Differentiation between neurogenic and mechanical causes of vocal cord immobility remains one of the most validated clinical applications of LEMG. In our cohort, patients with cricoarytenoid joint fixation demonstrated normal motor unit potentials and recruitment patterns, thereby preventing unnecessary medialization procedures and aligning management toward mechanical correction, as supported by previous studies [1,2]. Conversely, identification of established denervation allowed timely surgical intervention, consistent with evidence that early definitive treatment improves voice outcomes in irreversible paralysis [3,4].

In spasmodic dysphonia, task-specific hyperactivity and abnormal firing patterns on LEMG facilitated accurate classification and muscle selection for botulinum toxin therapy, corroborating its established role as the gold standard for guiding chemodenervation [5,6]. In presbyphonia, reduced recruitment

without active denervation reflected age-related neuromuscular atrophy, supporting conservative management or augmentation rather than reinnervation, as described in earlier literature [6,7]. Normal LEMG findings in puberphonia helped exclude organic pathology and reinforced its functional etiology, enabling focused behavioral therapy [8,9].

The application of LEMG in dysphagia, particularly for assessment of the cricopharyngeus muscle, proved valuable in identifying hypertonicity and impaired relaxation. LEMG-guided botulinum toxin injection offered a minimally invasive alternative to surgical myotomy with favorable outcomes, in line with published evidence [10,11]. Overall, this study highlights the versatility of LEMG in refining diagnosis, guiding targeted therapy, and optimizing patient-specific management in ENT practice.

Limitations

- Small sample size
- Limited dysphagia subgroup (n = 5)
- Single-center study
- No long-term follow-up beyond 12 months

Larger multicenter prospective studies are required to validate these findings and explore quantitative and AI-assisted waveform analysis.

Conclusion

Laryngeal electromyography plays a crucial role in enhancing diagnostic accuracy by providing objective assessment of laryngeal neuromuscular function. When combined with flexible videolaryngostroboscopy, it forms an advanced, complementary diagnostic approach for comprehensive evaluation of voice and airway disorders. Beyond vocal fold immobility, LEMG is valuable in prognostication of nerve recovery, evaluation of synkinesis, spasmodic dysphonia, presbyphonia, functional voice disorders, and dysphagia, including targeted assessment of the cricopharyngeus muscle. Its additional applications in LEMG-guided botulinum toxin injections and intraoperative nerve monitoring further expand its therapeutic and procedural utility, making it an indispensable tool in contemporary laryngology.

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