



Feasibility of Transcutaneous Electrical Nerve Stimulation for Evocation of Laryngeal Reflexes in Horses

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Background

- Equine **recurrent laryngeal neuropathy (RLN)** involves progressive degeneration of the **recurrent laryngeal nerve (RLN)**, resulting in laryngeal hemiparesis and exercise intolerance (see **Figure 1**)
- During an endoscopic procedure called the **Slap Test**, open-palm strikes on the dorsal aspect of the thorax evoke a **thoraco-laryngeal adduction reflex (TLAR)** used to evaluate laryngeal function (see **Figure 2**)
- We previously showed that analysis of **vocal fold (VF)** movement by in-house **VFtrack software** provides objectivity to the laryngeal exam (see **Figure 3**), but Slap Test stimulation remains subjective and inconsistent
- We hypothesize that transcutaneous electrical nerve stimulation (TENS) applied to the Slap Test target site can be used to improve objective evaluation of laryngeal function in horses**

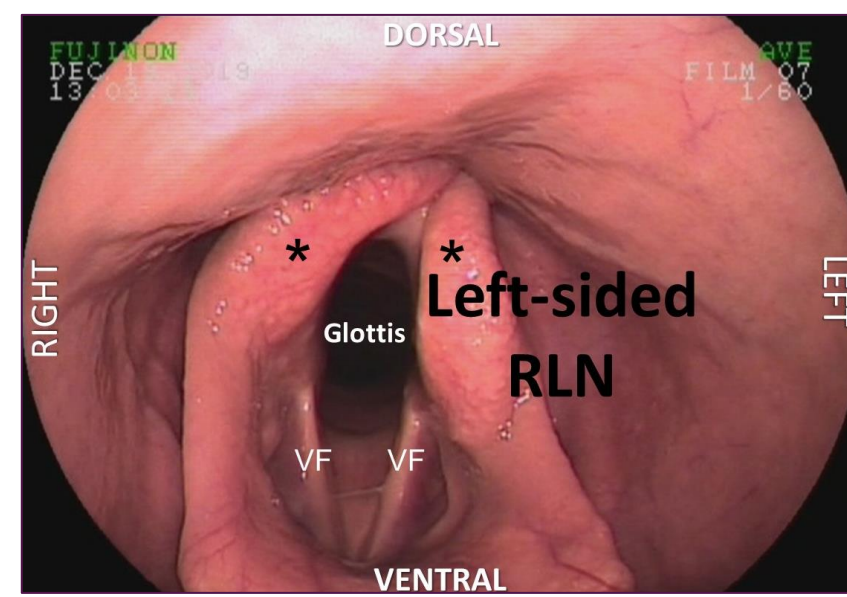


Figure 1. Endoscopic view of RLN. Left-sided paresis results in asymmetry of the vocal folds (VF) and arytenoid cartilages (*).

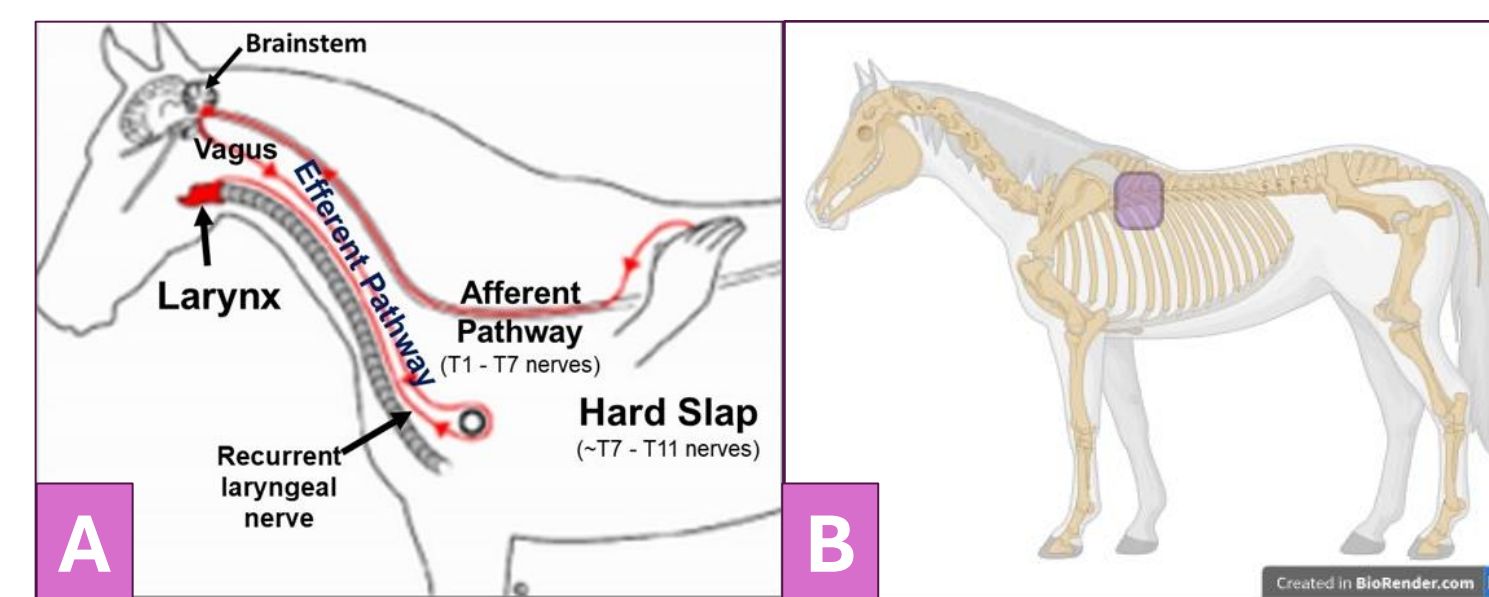


Figure 2. Slap Test. (A) Upon striking the dorsal aspect of the thorax, sensory nerves transmit signals to the brain, activating laryngeal adduction via the RLN. (B) Target stimulus locus between the 6th and 9th intercostal spaces.

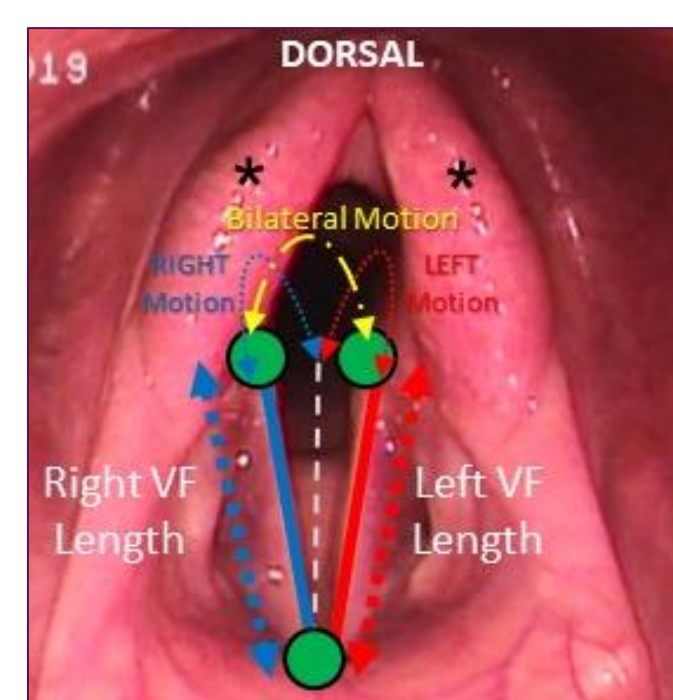


Figure 3. VFtrack software overlay. Motion of the left (red) and right (blue) VFs is traced in the software relative to the glottal midline (white dashes) and the ventral aspect of the VFs (lower green dot)

Objective

- Develop methodology to apply TENS to the dorsal aspect of the thorax of healthy horses as an alternative to the Slap Test for evoking the TLAR for objective analysis using VFtrack software

Methods

Horse Information

- Four geldings from MU's Research Farm tested
- Ages: 13 yr (n=1), 22 yr (n=3)
- Breeds: American Paint Horse (n=2), Rocky Mountain Horse (n=1), and American Quarter Horse (n=1)
- All considered healthy based on physical examination

Testing (L & R side)

- Performed Slap Test to define optimal stimulus locus
- Target area clipped in rectangular shape
- TENS probe applied parallel to ribs (see **Figure 4**)
- Calibrated proprietary waveform settings (frequency, pulse width, interphase delay)
- Intensity raised in 1 mA steps to no more than 14 mA
- Monitoring for muscle twitching or discomfort

Data Analysis

- Reviewed endoscopic footage for responses eligible for tracking (relaxed horse, steady field of view, etc.)
- Made 1-3 s clips of Slap Test and TENS responses
- Ran clip analysis in VFtrack software
- Compared Slap Test and TENS data for VF movement, derived TLAR, and adduction metrics

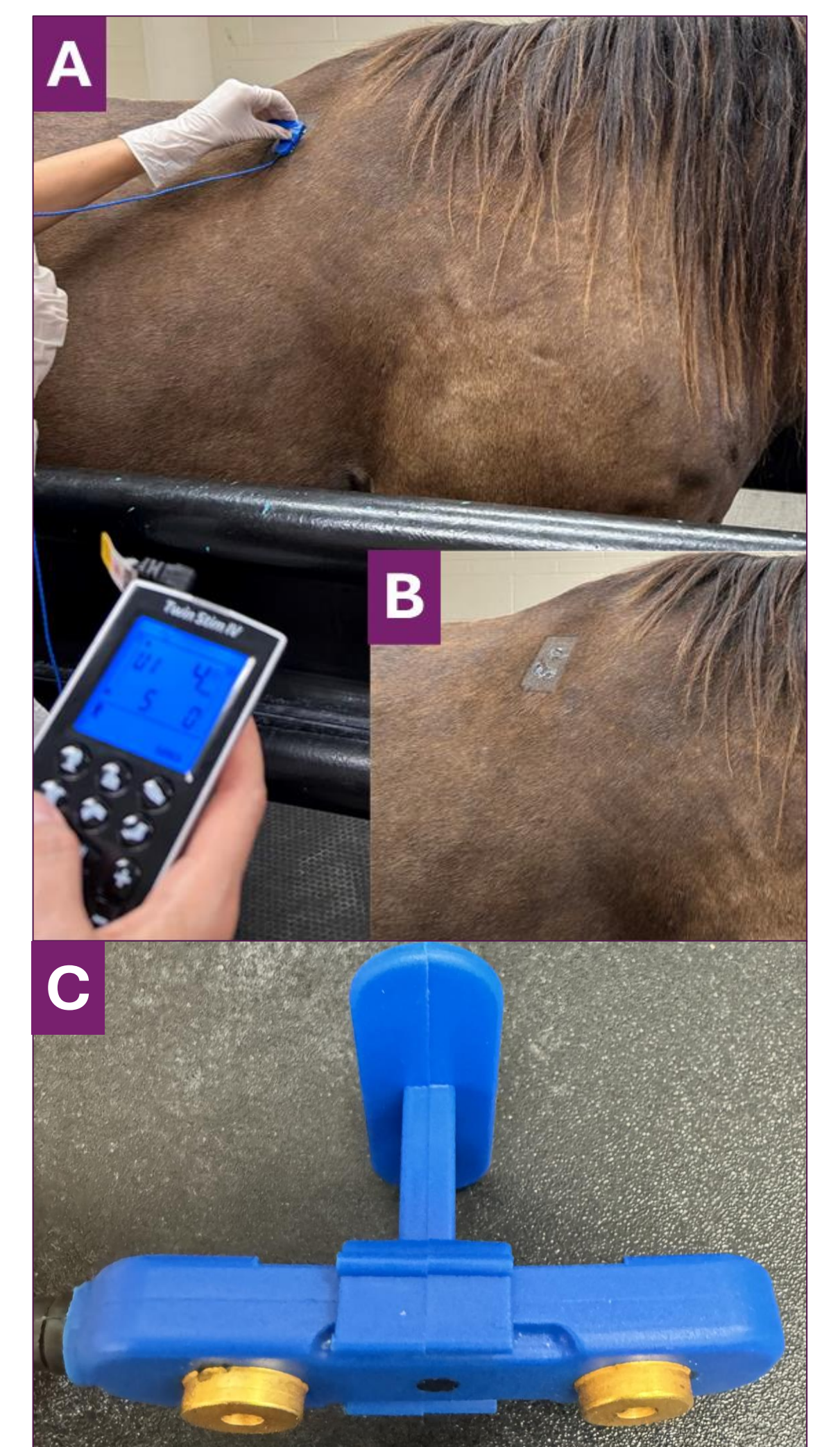


Figure 4. TENS device, site, and probe. (A) One tester applied probe, another operated device. (B) Detail of shaved stimulation site with residual electrode gel on skin. (C) Closeup of TENS probe (blue) and electrodes (gold).

Results

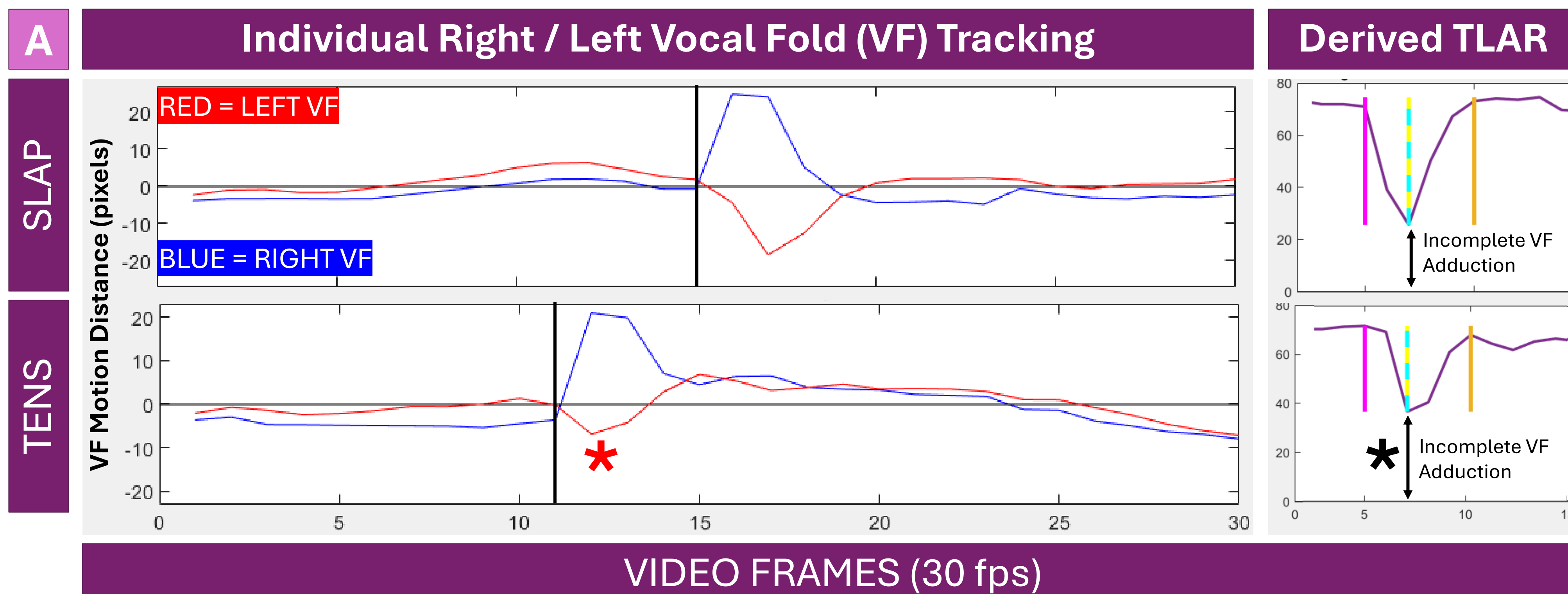
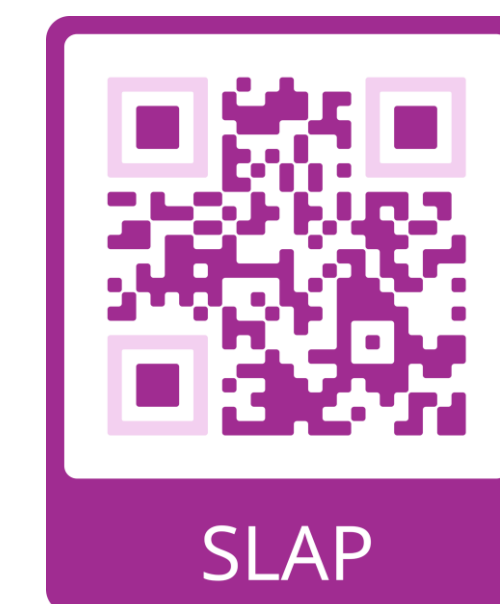


Figure 5. VFtrack data from one horse. (A) Left VF movement was reduced compared to the right during TLARs evoked by both methods (Slap Test and TENS) but was more readily apparent via TENS. The derived TLAR graphs from VF tracking indicated a lower degree of medialization with TENS compared to the Slap Test. (B) Schematic of VF motion, with colored tracking points (red=left, blue=right, green=ventral aspect) and directional arrows indicating angles of vocal fold displacement.

Table 1. Objective TLAR metrics quantified by VFtrack

TLAR Metrics	SLAP	TENS
VF Adduction Duration (ms)	67	67
Glottic Closure Duration (ms)	0	0
VF Abduction Duration (ms)	100	100
Total TLAR Duration (ms)	167	167
VF Angle at Max Adduction (degrees)	14	18



SLAP



TENS

- All horses tolerated TENS without adverse events; TLAR was evoked in only two
- The two horses without TENS-evoked TLARs had only slight responses to the Slap Test
- For one senior (age 22) American Paint Horse, VF tracking of TLARs identified diminished motion of the left VF (more readily apparent with TENS) (see **Figure 5**)
- Time-based TLAR metrics for this horse were identical for both methods (Slap Test and TENS), but the degree of VF adduction was less with TENS (see **Figure 5; Table 1**)
- The left side of this horse's larynx was asymmetrically positioned compared to the right, with corresponding reduced movement upon stimulation that was more accentuated with TENS than the Slap Test

Limitations:

- Suboptimal endoscopic illumination resulted in poor image resolution that interfered with objective analysis (see **Figure 6**)
- Adjustments to TENS device settings failed to evoke complete VF medialization in all horses
- Horses available for testing were a small sample of older horses

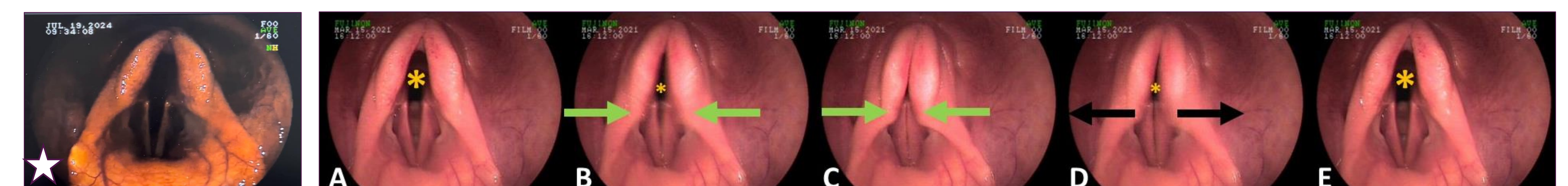


Figure 6. Current endoscopic imaging vs ideal imaging. (A-E) This endoscopy system, replaced before the current study, provided superior illumination for higher resolution images, showcasing the complete glottal space closure (gold asterisks) achieved during (B-D) a typical Slap Test-evoked TLAR compared to (A, E) breathing at rest. (F) Image from current endoscopy system. Note the lowered illumination and poor contrast between laryngeal structures and the glottal space.

Conclusions

- TENS applied at the dorsal aspect of the thorax evoked laryngeal adduction in some horses, but device constraints and/or individual animal variances contributed to inconsistent responses**
- VFtrack software detected laryngeal discrepancies more readily with TENS than the Slap Test, indicating that TENS has potential as an objective diagnostic tool if adequate parameter ranges can be established
- A convenience sample of horses conditioned to research participation may have contributed to their tolerance of TENS, and it is questionable whether clinical patients would tolerate the procedure
- The advanced age of most of the horses may have contributed to discrepancies between left and right VF movement, possibly due to age-related functional changes in laryngeal motility

Next Steps

- A prototype stimulator with broader parameter ranges and more precise adjustability is under development
- Goals for future testing include accessing diverse sample groups, improving endoscopic image quality, and incorporating the prototype in hopes of evoking a fully medialized TLAR and other laryngeal reflexes (swallowing)

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