

Equine Laryngeal Model for Training Surgical Residents



DEPARTMENT OF
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Background and Motivation

- Upper airway abnormalities
 - Cause distress to horses and exercise intolerance
- Techniques
 - Using a laser for the Transendoscopic Laser Ventriculocordectomy procedures
 - This cuts out the vocal folds out completely
- Training opportunities
 - Surgical residents currently have to wait for cadavers to practice the surgery
- Motivation
 - Surgical models can help residents practice procedures to have greater success when done on animals

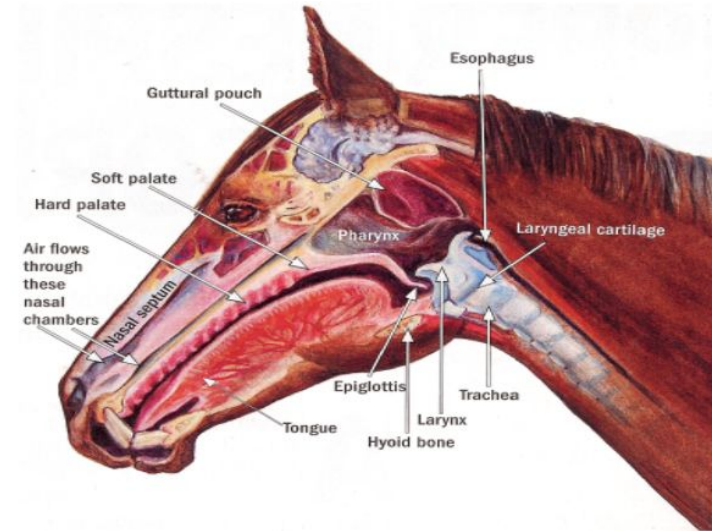


Figure 1: Labeled Horse Head [1]

Problem Statement

- **Problem**

- The design will imitate the anatomy and life-like size of an 4-6 year old adult horse's nostril to larynx
- The design should also accurately replicate the different types of tissues that are present in the larynx of a horse
- The vocal folds will be replaced after each surgery

- **Goal**

- Develop a reusable equine laryngeal model for training surgical residents for Transendoscopic Laser Ventriculordecotomy procedures



Figure 2:
Syndaver dog
model



Figure 3: Erler Zimmer
Foot of a Horse Model

PDS Summary

Performance requirements:

- Must imitate the anatomical size of an adult horse
- Must contain replaceable and static parts

Accuracy and reliability:

- Size should imitate the size of head of an average adult horse and the internals should replicate that of an equine upper airway

Life in service:

- The replaceable parts of the model should last one procedure, while the static portions should last for at least 20 years
- At least 14-28 surgeries will be performed per semester

Safety:

- Material used must safely interact with laser

Target Cost:

- The budget is \$1000 but can get more if needed.

Competition:

- SYNDaver [2]
- Erler Zimmer Foot of a Horse as Model [3]

PDS Summary

Mechanical Properties



Figure 4: Larynx taken from a horse

Table 1: Mechanical Properties of a Equine Upper Airway Anatomy [4] [5] [6]

Anatomical features	Young's Modulus	Yield Stress	Ultimate Strength	Error Approximations
Equine laryngeal cartilage	0.42 ~ 2.51 MPa	x	20 KJ/m ³	5% error
Bone	16 GPa	110 MPa	226 MPa	10% error
Muscle	1186 KPa	x	x	10% error

PDS Summary

Dimensions

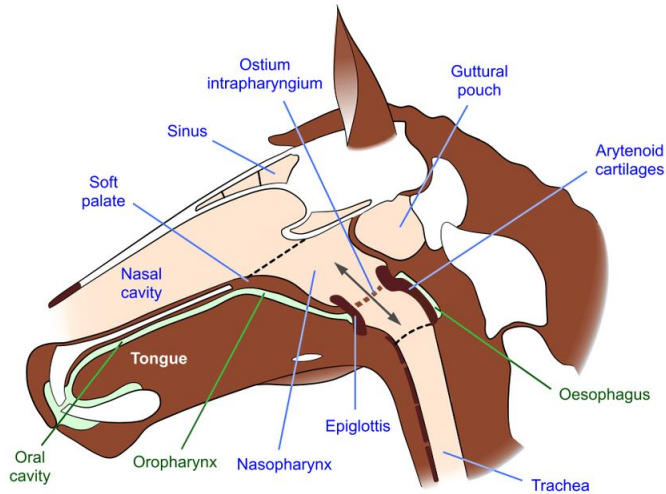


Figure 5: Horse head anatomy [7]

Anatomical Feature for a mature horse age of between (4-6)	Dimensions
Trachea	5.5cm diameter, 70 cm length
Larynx	7.62 centimeters in diameter, height around 5.87 cm
Nose	63.5 cm (circumference)
Head	114.3 cm (circumference)
Distance from cheek to back of jaw bones	25.4 cm
Nostril	1.9cm in width

Table 2: Mechanical Properties of a Equine's Upper Airway Anatomy [8] [9] [10] [11]

Design Idea 1

Replaceable Gelatin Vocal Folds

- Upscaling of a current human model for training surgical residents to replicate equine anatomy[12]
- Removable, 3D printed larynx with modified lateral cavities for vocal folds
- Gelatin vocal folds formed by a reusable silicone mold

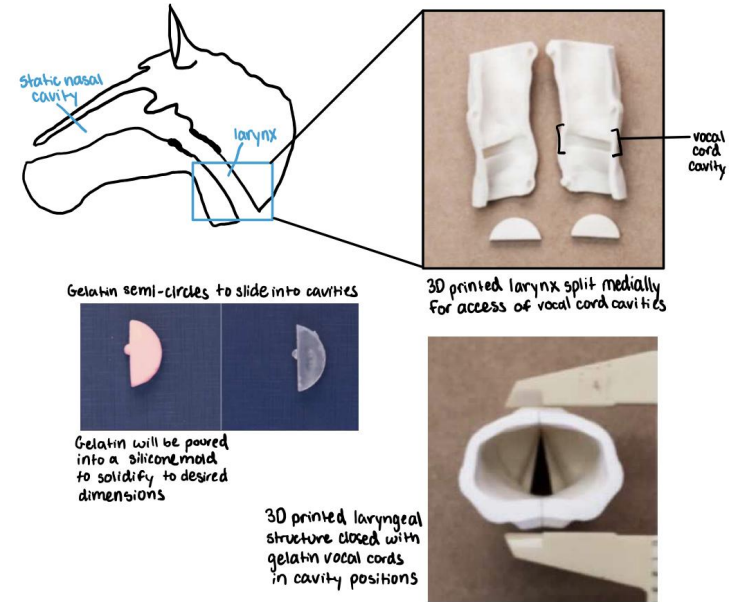


Figure 6: Replaceable Gelatin Vocal Folds

Design Idea 2

Replaceable Laryngeal disk

- Realistic larynx and nasal cavity
- Removable cartridge containing the vocal cords
 - Vocal cords attached to membrane strung on disk
- Secured by pin

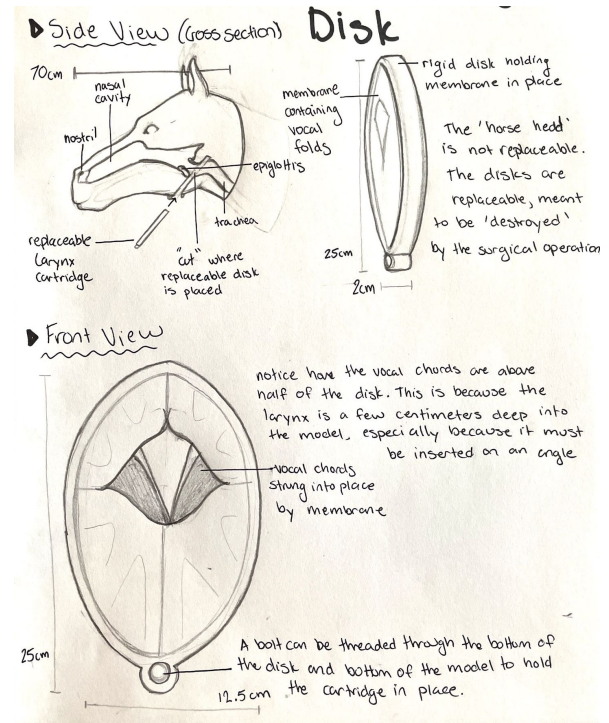


Figure 7: Replaceable Laryngeal Disk

Design Idea 3

Replaceable Laryngeal Tissues with Sensors

- Replica of sensors seen in competing SynDaver human surgical model along laryngeal cartilage [13]
- Replaceable vocal folds and laryngeal cartilages
- Realistic tissues made of salts, water, and fibers

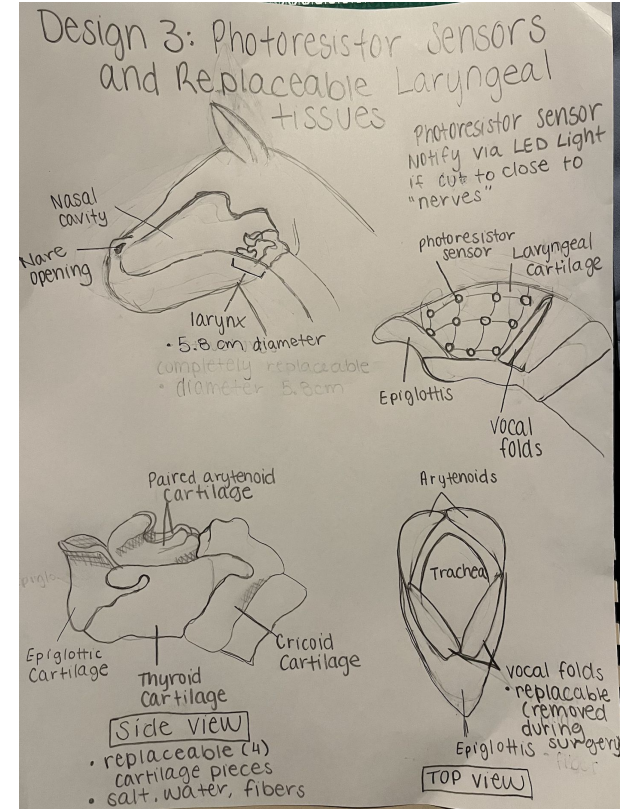


Figure 8: Replaceable laryngeal tissue with sensors

Design Matrix

- Replaceability
- Ease of Fabrication
- Accuracy and Reliability
- Safety
- Cost <\$1000
- Life in Service

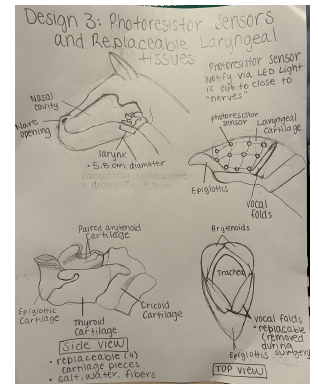
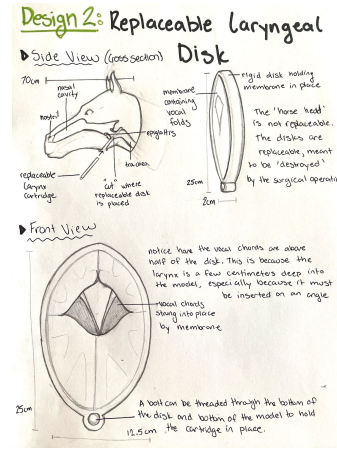
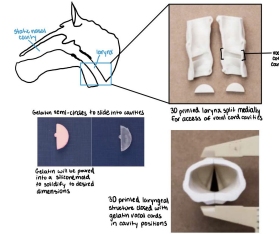
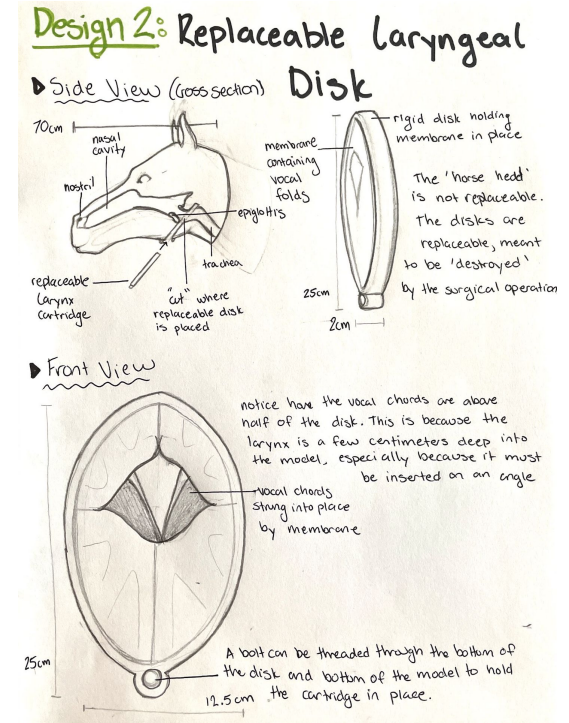


Figure 9: Design Ideas

Design Matrix

Criteria	Weight	Replaceable Gelatin Vocal Folds [1]		Replaceable Laryngeal Disk		Replaceable laryngeal tissues with sensors[2]	
		Score (5 Max)	Weighted score	Score (5 Max)	Weighted score	Score (5 Max)	Weighted score
Replaceability	30	4	24	3	18	1	6
Ease of Fabrication	20	3	12	4	16	1	4
Accuracy and Reliability	20	4	16	5	20	5	20
Safety	15	4	12	5	15	2	6
Cost	10	5	10	4	8	1	2
Life in Service	5	3	3	4	4	5	5
Total	100	Total	77	Total	81	Total	43

Table 3: Design Matrix for Overall Design



Future Work

1. Order materials for vocal folds
2. 3D scan and print CT files
3. Fabricate vocal folds component
4. Create test protocols for static and replaceable components

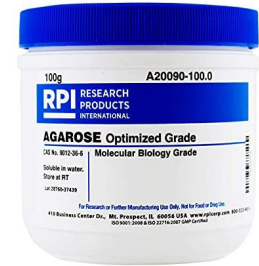


Figure 10: RPI Agarose Powder [14]

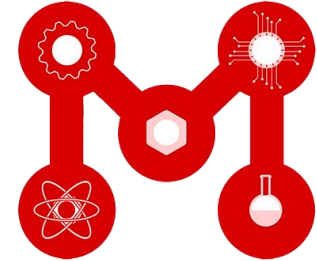


Figure 11: UW MakerSpace Logo [15]

Upcoming Project Goals

Purchase Materials

Friday, Oct. 14th

Fabricate replaceable components

Monday, Oct. 31st

Final Deliverables

Wednesday Dec. 14th

Fabricate static components

Monday, Oct. 24th

Testing Prototype

Friday, Nov. 18th



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Questions?

