Group 30: Biomechanical Work Analysis on Patients with Dysphagia Using High-Resolution Manometry and Impedance

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Background

- Dysphagia, or difficulty swallowing, affects 1 in 25 adults in the United States
- Only about 50% of dysphagia patients demonstrate abnormal **High Resolution Impedance Manometry (HRIM)** findings despite persistent symptoms [1]
- There is a need for a novel biomechanical assessment capable of quantifying the mechanical work generated by the esophagus during swallowing
- Approach would expand upon traditional HRIM by integrating **impedance-derived cross-sectional area (CSA)** measurements with **pressure** data

Objectives

- Evaluate patients with Eosinophilic Esophagitis (EoE) before and after Dupilumab treatment
- Develop a conductive swallow gel to **extend shelf life**
- Validate Impedance to cross-sectional area calculations
- **Calculate mechanical work** with MATLAB
- Analyze Upper and Lower Esophageal sphincter to assess regional work in EoE using HRIM and impedance catheter

Experimental Design Overview

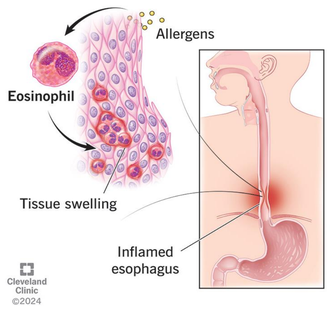


Fig. 1: Eosinophilic Esophagitis (EoE) cause and effects on esophageal tissue. [2]

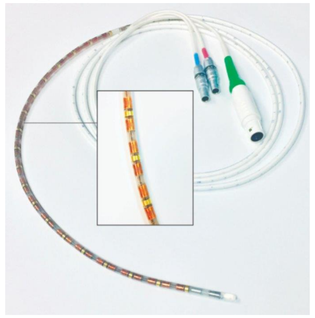


Fig. 2: Impedance Catheter used for High Resolution Impedance Manometry (HRIM) [3]

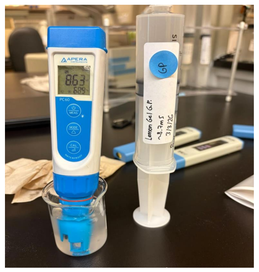


Fig. 3: Gel testing at timepoint for gel shelf life parameters (conductivity)

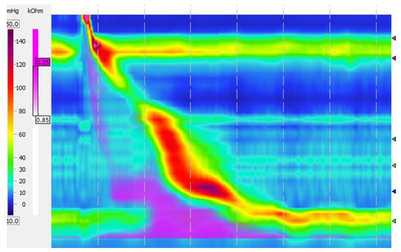
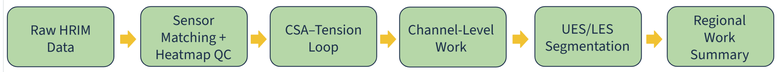


Fig. 4: HRIM plot of esophageal pressure and bolus transit during a swallow, used to assess changes in function.

HRIM Mechanical Work Analysis Pipeline



Results

Impedance to CSA Validation

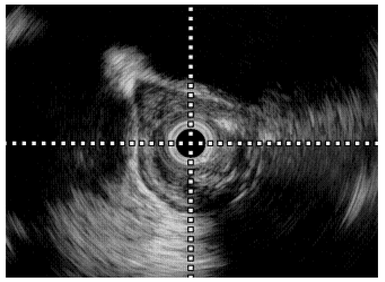


Fig 5: *Ultrasound Image of Esophagus* at maximum CSA. Luminal CSA was traced to compare with impedance-derived CSA

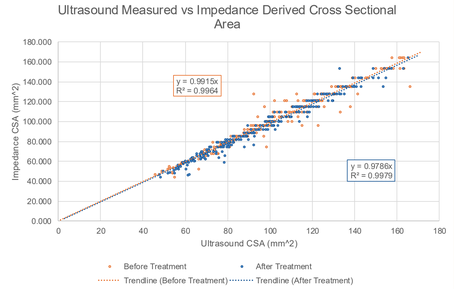


Fig 6: CSA ratios comparison between before-treatment and after-treatment. Strong correlations validate impedance CSA calculations.

Mechanical Work Calculations

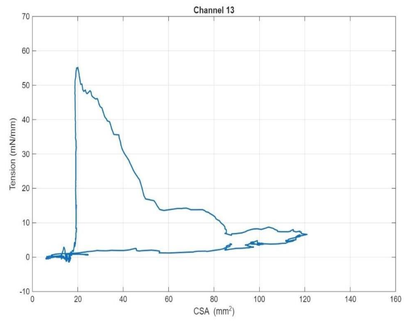


Fig. 7: *Representative CSA–Tension Loop*
A representative CSA–tension loop used to calculate mechanical work of one swallow for that channel.

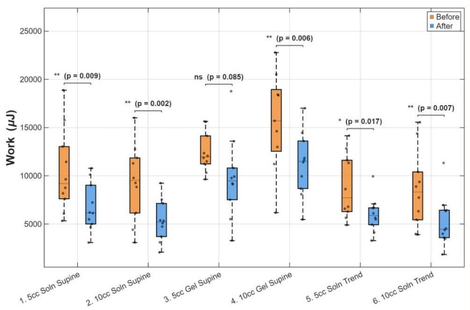


Fig. 8: *Total Swallow Work Across Conditions*
Total swallow work compared before and after treatment across patients under six conditions.

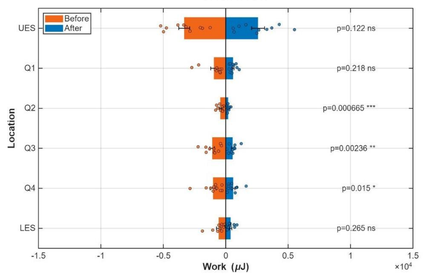


Fig. 9: *Regional Work Distribution Along Esophagus*
Work was compared before and after treatment along the length of the esophagus, from the upper esophageal sphincter (UES) through four esophageal body regions (Q1-Q4) to the lower esophageal sphincter (LES). Figure shows reduced post-treatment work, with significant decreases in the distal esophagus, especially Q2 to Q4.

Gel Reformulation

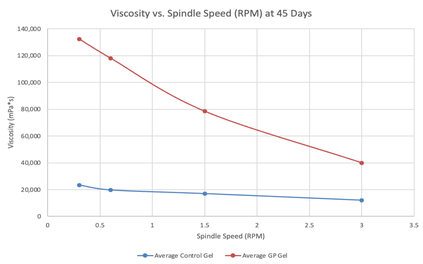


Fig. 10: Rotational Viscometer viscosity measurements of new gel recipe versus old (control) at 45 days timepoint

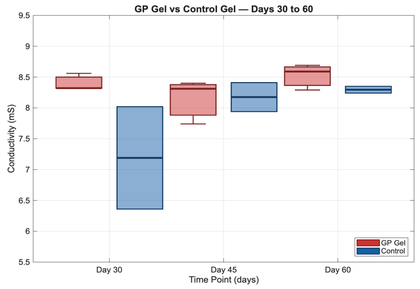


Fig. 11: Conductivity comparison over time between old gel recipe and new gel recipe.

Symptom Improvement

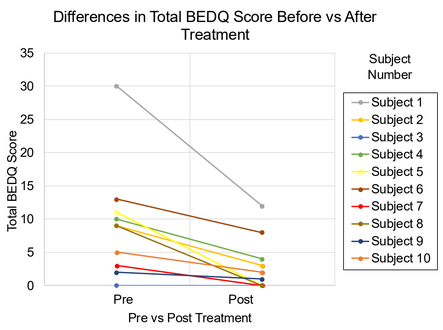


Fig. 12: Each line represents a participant's total BEDQ score pre- and post-treatment. The BEDQ assesses swallowing difficulty, frequency of symptoms, and associated discomfort, with items rated on a 0-5 scale (e.g. 0 = "Never/Rarely," 5 = "Several times a day") with a total possible score from 0-40.

Distal Esophagus Eosinophils Count (per HPF) Before and After Treatment

Subject #	Pre Treatment Count (per HPF)	Post Treatment Count (per HPF)
1	30	0
2	50	0
3	50	0
4	40	25
5	100	0
6	50	0
7	50	5
8	30	10
9	15	0
10	20	3

Table 1: Distal esophageal eosinophil counts decreased in all participants of the clinical trial, with most achieving histologic remission.

Key Findings

- ☑ Novel swallow gel showed less conductivity variation and improved viscosity, showing increased stability
- ☑ Swallow work quantification demonstrated **significantly reduced esophageal mechanical work** following treatment in 5 of 6 conditions
- ☑ Mechanical work significantly decreased in the distal esophagus region compared to upper and lower sphincter regions after treatment

Discussion

- Improved swallowing symptoms and reduced mechanical work during bolus transport, indicate efficient swallowing after treatment with Dupilumab
- Findings highlight the potential of biomechanical HRIM analysis to provide clinically meaningful information beyond current manometry metrics
- Data analysis limited by small size of cohort

Future Directions

- Compare treated patients with healthy control groups
- Expand the clinical trial cohort with additional completed patients
- Incorporate additional biomechanical parameters, including stress, strain, and power

Acknowledgements & References

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Scan the QR code for full references: