Reducing Surgical Smoke Exposure in Rhinologic Electrosurgery: A Pilot Evaluation of a Novel Evacuation Device

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BACKGROUND

- Surgical smoke exposure is a growing occupational hazard in endoscopic sinus and skull base surgery[1]
- Powered instrumentation, electrocautery, and energy-delivery devices generate aerosolized particulate matter (PM) composed of aerosolized blood, tissue particulates, and combustion byproducts[2]
- PM exposure is associated with acute respiratory and mucosal irritation and potential long-term health risks[3,4]
- We present a novel Nasopharyngeal Suction System (NSS) and evaluate its performance in a benchtop simulation model (Fig. 1A)

METHODS

- A custom, anatomically-representative nasopharyngeal phantom model was developed from deidentified CT datasets (Fig. 1B)
- Electrocautery smoke generated by cauterizing porcine tissue
- Ten trials per condition (NSS vs control), each with 60s baseline, 60s active electrocautery, and 120s post-cautery
- PM1 and PM2.5 recorded at 1s intervals in surgical field and operator breathing zone
- Two-way ANOVA and Šídák's multiple-comparisons test performed on trial-level averages, adjusted p-values reported

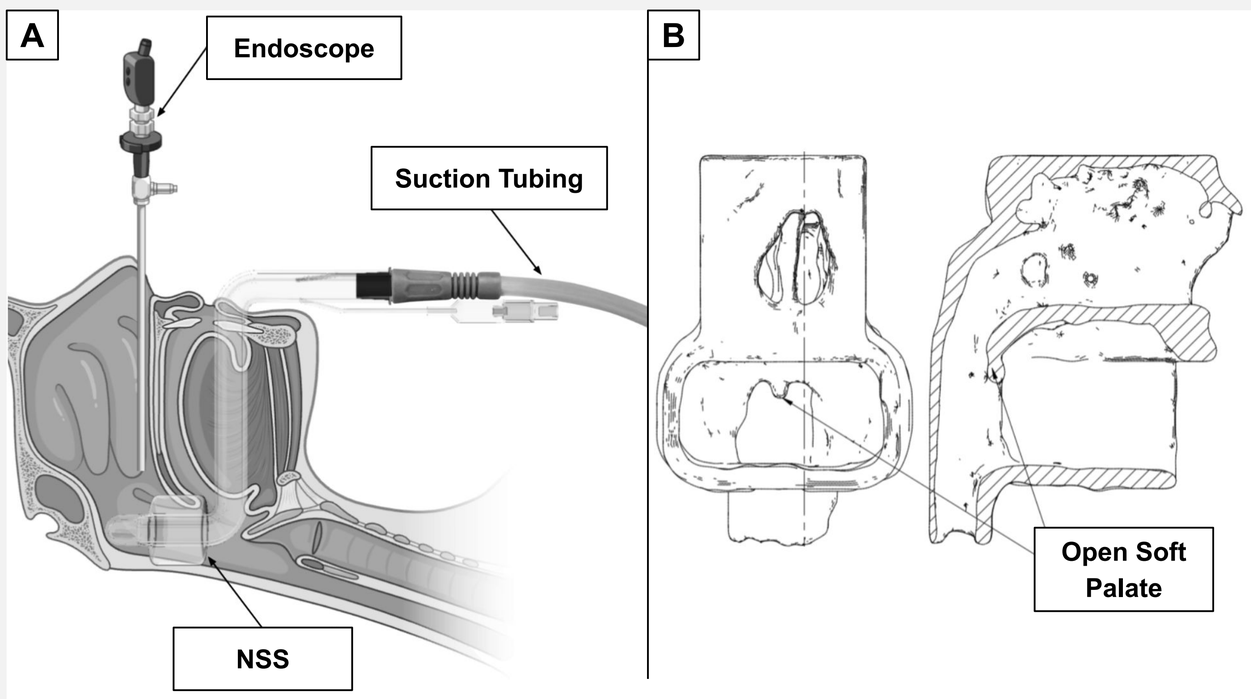

Figure 1: Nasopharyngeal phantom model design. **(A)** NSS inserted orally. **(B)** Phantom model configuration with open soft palate for NSS placement.

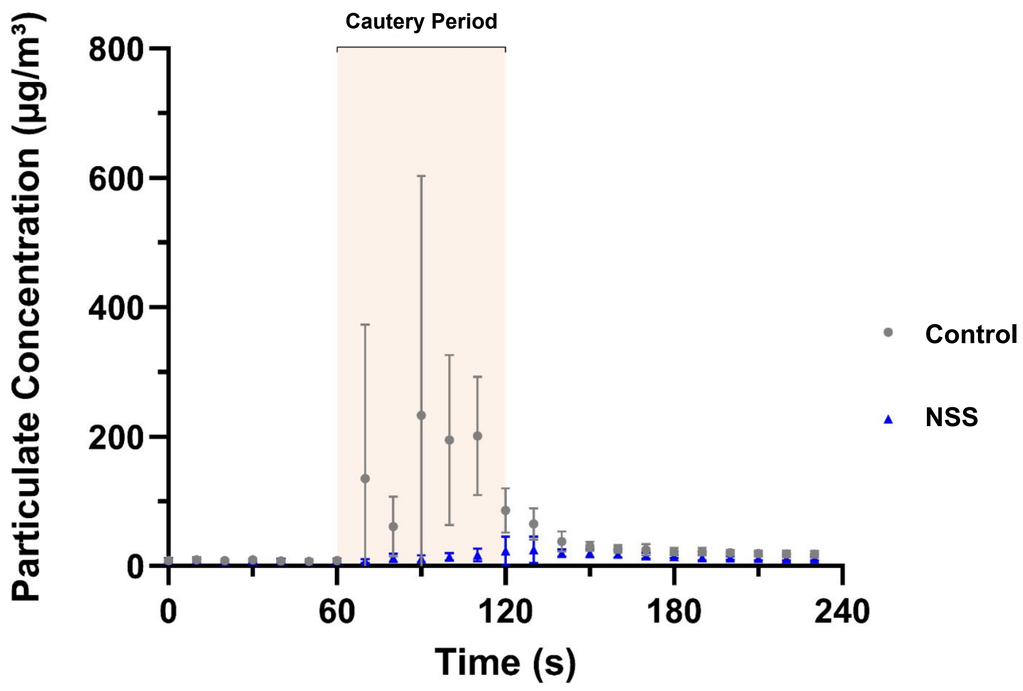

Figure 2: PM2.5 concentrations in the operator breathing zone. PM2.5 (µg/m³) during electrocautery activation and recovery for control and NSS trials.

RESULTS

Surgical Field (, p<0.0001)**

- Peak PM1: 3618 µg/m³ (control) vs. 24.5 µg/m³ (NSS; −99.3%)
- Peak PM2.5: 3645 µg/m³ (control) vs. 24.5 µg/m³ (NSS; −99.3%)
- Mean PM1: 173.6 µg/m³ (control) vs. 15.5 µg/m³ (NSS; −91.1%)**
- Mean PM2.5: 177.5 µg/m³ (control) vs. 15.6 µg/m³ (NSS; −91.2%)**

Operator Level (, p<0.0001; Fig. 2)**

- Peak PM2.5: 426.1 µg/m³ (control) vs. 25.0 µg/m³ (NSS; −94.1%)
- Mean PM2.5: 58.9 µg/m³ (control) vs. 13.0 µg/m³ (NSS; −78.0%)**

During Electrocautery (, p<0.0001; Fig. 3)**

- Mean PM1: 541.8 µg/m³ (control) vs. 14.50 µg/m³ (NSS; −97.3%)**
- Mean PM2.5: 157.2 µg/m³ (control) vs. 12.68 µg/m³ (NSS; −91.9%)**

NSS significantly reduced PM:

- Across multiple size fractions
- In both surgical field and operator breathing zone
- During and after electrocautery period

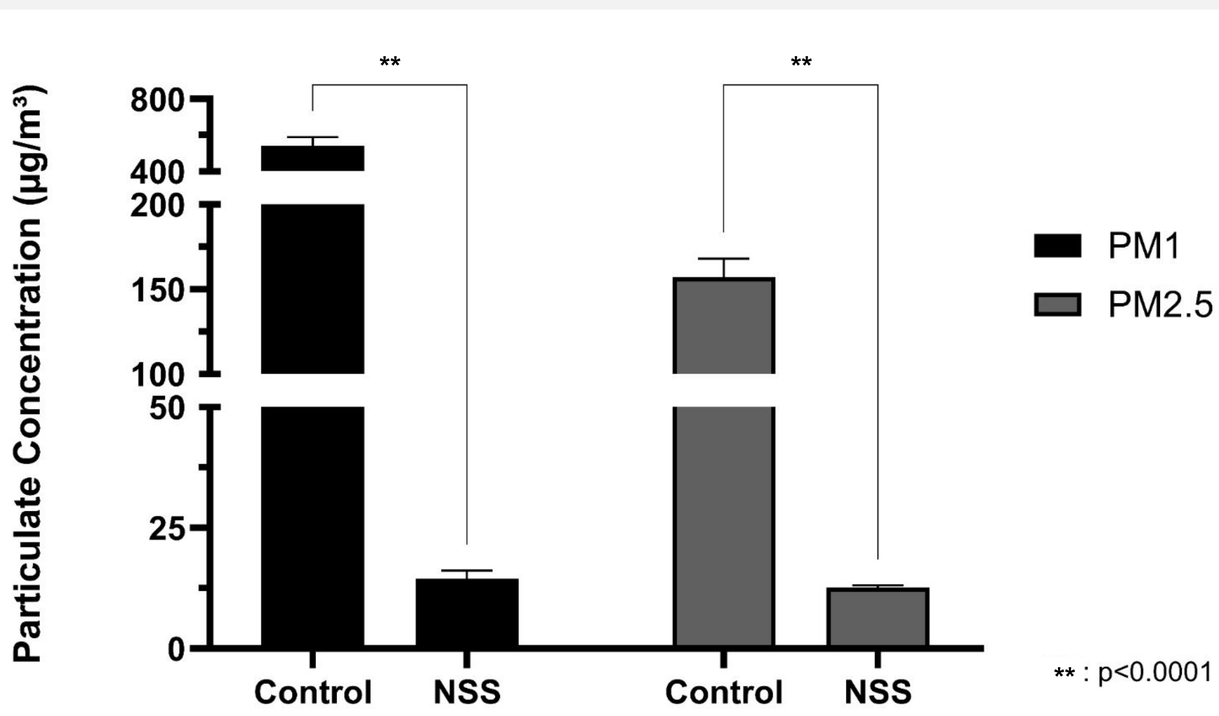

Figure 3: Mean particulate concentrations during electrocautery. Mean PM1 and PM2.5 (µg/m³) in the surgical field during electrocautery under control and NSS conditions.

CONCLUSIONS

- NSS significantly reduced clinically-relevant PM size fractions when compared to control
- The NSS can provide continuous, source-level PM evacuation in a benchtop endonasal surgery simulation model
- These findings support continued preclinical development of the NSS and justify staged evaluation in animal and early-phase clinical trials

REFERENCES

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