



Reduction of Intraoperative Particle Transmission Using a Novel Nasal Port Device

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Objective: To evaluate the effectiveness of a novel nasal port device with a vacuum chamber in containing airborne particles during endoscopic sinus and skull base surgery using a 3D printed nasal airway model.

Background

- Endoscopic sinus and skull base surgeries are increasingly used for sinonasal and skull base procedures
- The COVID-19 pandemic highlighted the risk of aerosol transmission during these procedures, underscoring the need for improved protective strategies.
- Standard infection control methods reduce but do not fully eliminate aerosol exposure for surgical staff.

Methods



Device Design: A nasal port with was designed in SolidWorks, 3D printed in resin, and fitted with a flexible silicone base. It was secured to a silicone nasopharyngeal model replicating nasal anatomy.

Figure 1. 3D-printed device nasal port device designed for particle capture, including a flexible nasal insert to ensure secure fit on the nose.

Figure 2. Experimental setup with the nasal port connected to controlled suction and a particle mister.



Setup: The port was connected to a dual vacuum pump (50 kPa). A mist machine (5–20 μm droplets) simulated particle generation, recorded using a Photron FASTCAM high-speed camera.

Experimental Conditions: Three conditions (10 trials each) were tested:

(1) Control Group: No Port (2) Port Only without Suction (3) Port with Suction

Particle Analysis: Light intensity (85–200 a.u.) was extracted from video frames, baseline-corrected, and averaged to quantify particle density.

Results

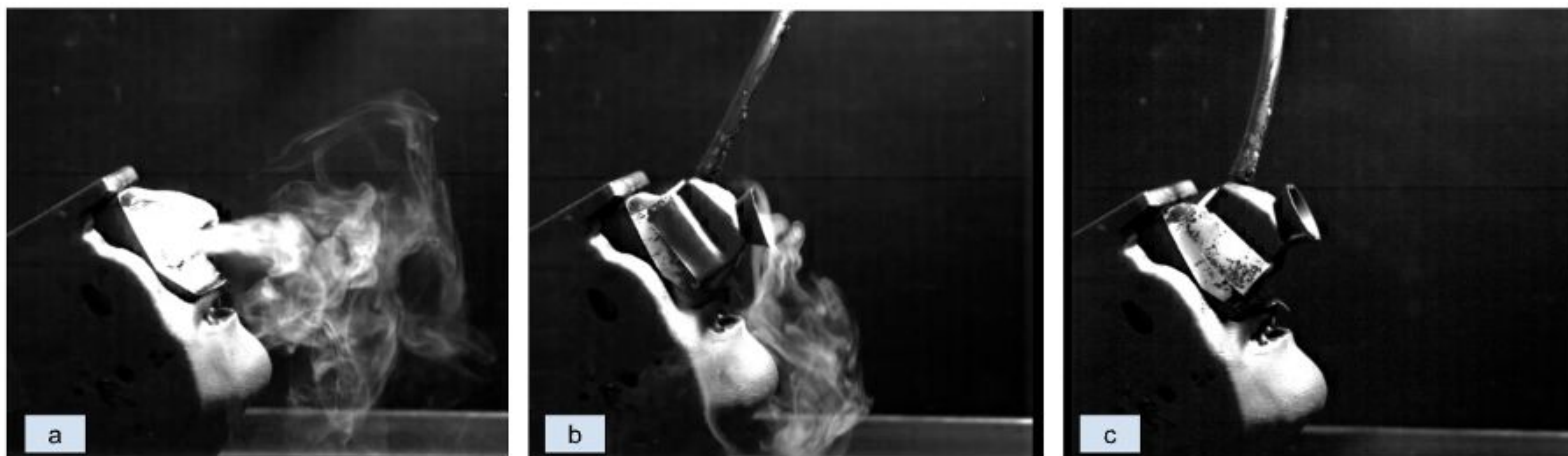


Figure 3. Images from videos taken in (a) 'No Port' condition (b) 'Port Only' condition and (c) 'Port and Suction' conditions using high-speed velocimetry

- Average total light intensity per frame:
 - Highest in the NP condition ($67,620 \pm 15,403$)
 - Reduced in the PO condition ($47,945 \pm 13,598$)
 - Lowest with PS condition ($10,464 \pm 2,013$).
- Repeated-measures ANOVA showed a **significant effect of condition on particle density** ($F(2,18) = 89.81, p < 0.001$).
- Post hoc testing confirmed significant differences between all groups ($p < 0.001$).
- Effect Sizes demonstrated large reductions observed between
 - NP vs. PO ($d = 1.35$)
 - PO vs. PS ($d = 3.86$)
 - NP vs. PS ($d = 5.20$).
- Relative to the NP control group
 - **PO condition achieved a 29% particle density reduction**
 - **PS condition achieved an 85% particle density reduction.**

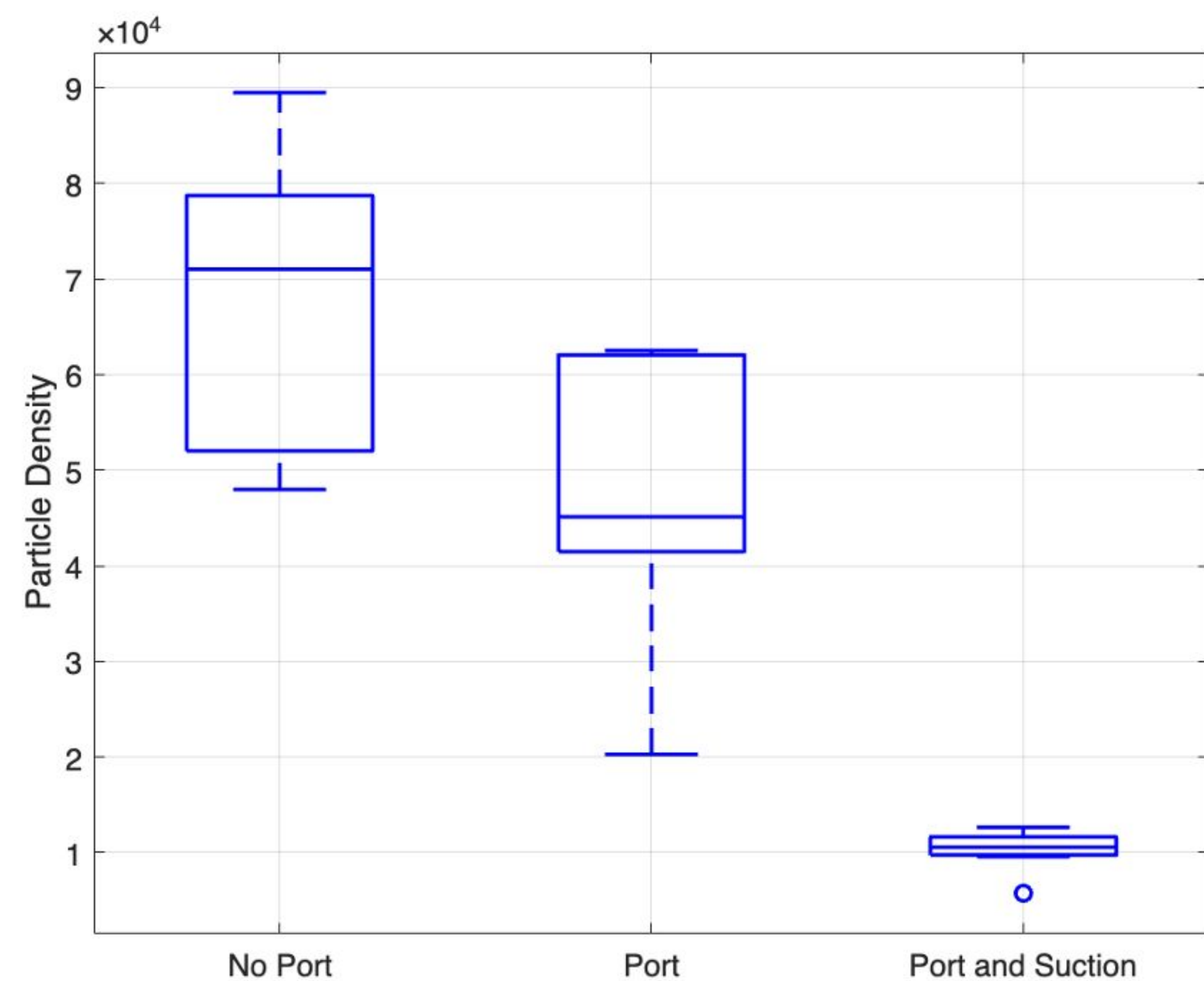


Figure 4. Distribution of particle density measurements (in a.u.) across trials for each condition, showing a consistent reduction in particle density with port and suction use

Conclusions

- The nasal port device with suction offers a method to reduce aerosol spread during endoscopic sinonasal surgery, addressing residual risks beyond existing PPE and environmental controls
- This device is unique in preserving surgical access and visibility, unlike more restrictive barrier methods and source control methods
- Limitations include testing in a synthetic nasal model rather than live tissue, use of simulated particles that do not fully mimic surgical aerosols, and evaluation of only a single device design.
- Future studies should assess performance with surgical instruments, smaller particle sizes, and cadaver or clinical models.