Zero-Degree Endoscopic Visualization of the Frontal Sinus Predicts Improved Topical Irrigation Delivery

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**Objective:** Management of chronic frontal rhinosinusitis is challenging with high rates of treatment failure, exacerbated by limitations of topical irrigation delivery. We hypothesize that intraoperative zero-degree visualization of the frontal sinus predicts improved postoperative irrigation penetration. Extending a Draf IIa frontal sinusotomy with a limited resection of the middle turbinate axilla-agger nasi complex can allow zero-degree endoscopic visualization of the frontal sinus. This study investigates the change in frontal sinus irrigation delivery after standard Draf IIa frontal sinusotomy versus further resection to achieve zero-degree visualization.

**Study Design:** This is a prospective cohort study conducted in a surgical skills laboratory.

**Methods:** The extent of irrigant penetration into the frontal sinuses was evaluated in 10 cadaveric frontal sinuses following Draf IIa sinusotomy using a standardized trephine visualization model. Irrigant penetration was assessed by three blinded reviewers using the following scale: 0 = irrigation restricted to nasal cavity; 1 = irrigation reaches frontal recess; 2 = irrigation reaches frontal sinus proper; 3 = irrigation fills entire frontal sinus. These results were compared to irrigation after achieving zero-degree endoscopic visualization by performing limited resection of the middle turbinate axilla-agger nasi complex.

**Results:** Irrigant penetration following standard Draf IIa frontal sinusotomy improved after the axilla-agger nasi complex was resected to achieve zero-degree endoscopic visualization (median score 2 [interquartile range: 1–2] vs. 3 [interquartile range: 2–3], P < .01).

**Conclusion:** This study demonstrates improved penetration of frontal sinus irrigation following limited resection of the middle turbinate axilla-agger nasi complex to achieve zero-degree endoscopic visualization of the frontal sinus as compared to standard Draf IIa frontal sinusotomy.

**Key Words:** Frontal sinusotomy, irrigations, chronic rhinosinusitis, endoscopic sinus surgery, FESS.

**Level of Evidence:** N/A

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**INTRODUCTION**

In patients with chronic rhinosinusitis (CRS) refractory to medical management, surgical enlargement of sinus ostia relieves obstruction and improves the delivery of topical irrigation, corticosteroids, and antibiotics, important components of long-term disease control.1 However, eradication of frontal sinus disease in particular remains one of the most challenging aspects of CRS management. Of patients undergoing primary endoscopic sinus surgery (ESS) with frontal sinusotomy, 7.6% to 8.9% will require a second frontal sinus procedure in the future.2–4 This figure increases substantially (17.2–29.9%) in patients undergoing a revision frontal sinus operation.4,5 Mucosal disease and retained frontoethmoidal partitions are implicated in the vast majority of frontal sinus treatment failures.4,5 The narrow frontal sinus ostium makes it susceptible to obstruction and scarring, thus contributing to higher rates of treatment failure. In recent years, topical irrigation delivery access has been increasingly recognized as a primary benefit of ESS. However, frontal sinuses, even in patients who have undergone Draf IIa procedures, receive limited topical delivery of irrigants.6,7 Poor delivery of irrigation and nasal corticosteroids likely contribute to the higher rates of observed treatment failure in inflammatory sinus disease.

The average dimensions of the frontal sinus ostium are 7.22 × 8.92 mm.8 The anterior border of the frontal sinus outflow tract is defined by the agger nasi cell. The standard Draf IIa frontal sinusotomy involves opening the posterior wall of the agger nasi, the so-called “uncapping of the egg” technique.9 Some have studied the additional utility of removing the anterior wall of the agger nasi and the axilla of the middle turbinate in their approach to the frontal sinus for improved visualization of the frontal recess.10,11

We hypothesize that achieving intraoperative zero-degree visualization of the frontal recess by resecting the middle turbinate axilla-agger nasi complex (MTAN) improves postoperative irrigation penetration. The MTAN is formed by two segments of bone: the frontal process of the maxilla and the nasal process of the frontal bone. The objective of this study is to investigate the change in frontal sinus irrigation following this extension...
METHODS

Five fresh cadaveric heads were obtained from Science Care (Phoenix, Arizona). The average age of the cadaver specimens was 71.4 years old (range 39–89), consisting of four males and one female. The study was conducted in a surgical skills laboratory at the Columbia University Irving Medical Center and is exempt from Institutional Review Board approval because no live human subjects were affected. Thin cut CT sinus scans were analyzed pre-study for each cadaver to confirm that there was no evidence of prior sinus surgery.

Frontal Sinus Trephination Technique

Frontal sinus trephines were performed in a standardized location 1 cm lateral to the midline at the level of the supraorbital rim. This location has been previously described as a consistent and safe trephine site. The trephine was made using a 5-mm drill bit to accommodate a 4-mm 70-degree endoscope looking inferiorly during endonasal irrigation.

Surgical Technique

Routine endoscopic sinus surgery was performed. This included bilateral uncinectomy, maxillary antrostomy, total ethmoidectomy, sphenoideotomy, and standard Draf IIa frontal sinusotom, including removal of all frontoethmoidal, suprabulla, and intersinus septal partitions. The anterior wall of the agger nasi was left intact.

Irrigation Technique

A 70-degree endoscope was inserted into the frontal sinus trephine on one side, obtaining a clear view of the frontal sinus and the frontal recess. The cadaver head was securely positioned

![Image](image_url)
at an angle of 45 degrees head-down, to approximate the conventional head position for saline irrigation. A NeilMed Sinus Rinse bottle (NeilMed Pharmaceuticals, Inc. Santa Rosa, CA) filled with 240 mL of water was irrigated into the ipsilateral naris. The entire bottle was emptied in two squeezes of the bottle. Video recording captured footage of the frontal sinus during irrigation. The same procedure was performed on the contralateral side. To maintain uniformity, one author performed both pre- and post-irrigations on all cadavers.

**Middle Turbinate Axilla-Agger Nasi Complex Resection**

Using a 2-mm Kerrison bone rongeur, the axilla of the middle turbinate was resected along with the anterior face of the agger nasi bilaterally to achieve zero-degree endoscopic visualization of the frontal sinus (Figs. 1 and 2). Zero-degree endoscopic visualization of the frontal sinus was defined as obtaining a clear view of the posterior table of the sinus. The middle turbinate itself remained attached in situ. This procedure was performed on each cadaver by the senior author to maintain uniformity. The irrigation procedure was again performed and recorded on each side in the same fashion.

**Endoscopic Evaluation**

Each video recording was edited and cropped to ensure anonymity. The recordings were distributed to three blinded reviewers, two attending rhinologists and one rhinology fellow. The videos were reviewed in random order. Scores were assigned separately by each reviewer according to the following scale: 0 = irrigation restricted to nasal cavity; 1 = irrigation reaches frontal recess; 2 = irrigation reaches frontal sinus proper; 3 = irrigation fills entire sinus (Table I). Representative still shots corresponding to each fill level denoted by the scale are seen in Figure 3.

**Statistical Analysis**

Data was analyzed using STATA version 15.1 (STATA, College Station, TX). Median scores were calculated for each endoscopic recording. The two-tailed Wilcoxon Matched-Pair Signed-Rank test was used to compare groups given the non-parametric nature of the data. Alpha < 0.01 was utilized. Interrater reliability was calculated using Cronbach’s alpha to ensure consistency amongst the blinded reviewers. Cronbach’s alpha is calculated on a scale of 0–1, with higher ratios signifying greater consistency.13

| Score | Extent of Irrigation       |
|-------|---------------------------|
| 0     | Restricted to nasal cavity|
| 1     | Reaches frontal recess    |
| 2     | Reaches frontal sinus proper |
| 3     | Filling of entire sinus   |

**TABLE I. Endoscopic Grading Scale.**

Fig. 3. Still shots demonstrating representative frontal sinus fill levels according to the Endoscopic Grading Scale (Table I). 0 = irrigation restricted to nasal cavity; 1 = irrigation reaches frontal recess; 2 = irrigation reaches frontal sinus proper; 3 = irrigation fills entire sinus.
RESULTS

Five cadavers were utilized and the above procedure was performed on all 10 frontal sinuses. Irrigant penetration following standard Draf IIa frontal sinusotomy improved after the axilla-agger nasi complex was resected to achieve zero-degree endoscopic visualization of the frontal sinus. The median endoscopic score for irrigant penetration following standard Draf IIa procedure was 2 (interquartile range [IQR]: 1–2). The median endoscopic score for irrigant penetration after additional dissection of the MTAN complex increased to 3 (IQR: 2–3; \(P < .01\); Table II). Inter-rater reliability of the three reviewers was calculated at 0.966, as measured by Cronbach's alpha, signifying excellent consistency between reviewers.

DISCUSSION

The first important revelation of this research is the relatively limited penetration of irrigation even after a standard frontal sinusotomy with a Draf IIa technique to open the frontal recess. This study demonstrates a statistically significant improvement in the volume of irrigation that penetrated the frontal sinus after performing a limited resection of the MTAN complex to achieve zero-degree visualization of the frontal sinus. This finding suggests that these structures directly obstruct the trajectory of irrigant from the nares to the frontal recess in a 45-degree head-down model, which approximates a patient leaning forward over a sink. Improved delivery of topical therapy to the frontal sinus may result in a lower rate of treatment failures.

Three studies have investigated the effects of various frontal sinus procedures on frontal sinus irrigation. Barham et al. compared Draf III to Draf IIa frontal sinusotomy and noted dramatic improvement in the volume of irrigation that penetrated the frontal sinus after performing a limited resection of the MTAN complex to achieve zero-degree visualization of the frontal sinus. This finding suggests that these structures directly obstruct the trajectory of irrigant from the nares to the frontal recess in a 45-degree head-down model, which approximates a patient leaning forward over a sink. Improved delivery of topical therapy to the frontal sinus may result in a lower rate of treatment failures.

In this study, we also describe a new model to evaluate frontal sinus irrigation. Similar to the study reported by Barham et al. we recorded irrigation via a frontal sinus trephine. However, we performed frontal sinus trephines 1 cm lateral to midline at the supraorbital rim because this is the safest location to make a trephine that will reliably be lateral to the intersinus septum and remain within the sinus. In our experience, the use of a 70-degree endoscope provided the best visualization.

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This study is limited by its small sample size and the cadaveric nature of the model. While many hypothesize that insufficient delivery of topical irrigation contributes to treatment failure, well-designed studies are necessary to evaluate rates of failed frontal sinusotomy with MTAN complex resection.

| TABLE II. Median Endoscopic Irrigation Score. |
|---------------------------------------------|
| Draf IIa Median (IQR) | Draf IIa + MT Axilla Resection Median (IQR) |
|-----------------------|-------------------------------------------|
| Median endoscopic irrigation score (n = 10) | 2 (1–2) | 3 (2–3) |
| *Difference between paired specimens pre and post MT axilla resection is statistically significant as calculated by Wilcoxon Matched-Pair Signed-Rank Test using alpha < 0.01. |
| IQR = interquartile range; MT = middle turbinate. |

Fig. 4. Head at 45-degree angle in sinus rinse position, demonstrating trajectory of irrigation into the nasal cavity, mirroring that of a zero-degree endoscopic view.
This study demonstrates improved penetration of nasal cavity irrigation to the frontal sinuses following removal of the MTAN complex to achieve intraoperative zero-degree visualization of the frontal sinus. This technique achieved significantly improved irrigation penetration compared to a standard Draf IIa frontal sinusotomy in a novel cadaver trephine model. This finding may guide the extent of intraoperative surgical dissection as a proxy for achieving optimal postoperative topical irrigation access.

CONCLUSION

This study demonstrates improved penetration of nasal cavity irrigation to the frontal sinuses following removal of the MTAN complex to achieve intraoperative zero-degree visualization of the frontal sinus. This technique achieved significantly improved irrigation penetration compared to a standard Draf IIa frontal sinusotomy in a novel cadaver trephine model. This finding may guide the extent of intraoperative surgical dissection as a proxy for achieving optimal postoperative topical irrigation access.

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