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Assessment of endoscopic and external approaches for frontal sinus lesions

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Abstract

Objectives: The use of endoscopic approaches has revolutionized the management of frontal sinus (FS) lesions. However, external approaches still play a significant role in select conditions. Various factors determine the decision to utilize endoscopic or external approaches such as the lesion location, extension, and patient's characteristics. The study aims to define certain FS indices for accurate selection of the most suitable approach for each patient.

Methods: A descriptive study was performed, based on endoscopic and external cadaveric dissections. Quantitative analyses including horizontal, anteroposterior diameters, and exposure area were performed for each approach using the navigation system. Patients with various FS lesions were included and their data were collected and evaluated.

Results: Fifteen cadavers were analyzed. The average anteroposterior diameter on the midsagittal plane was 12.3 mm, distance from the midline to the lateralmost point was 21.8 mm on the right and 23.1 mm on the left side. The exposure area on the right side for Draf IIa, and Draf IIb were 64.6, 115.0 mm² while on the left side were 67.0, 125.0 mm². For Draf III, the exposure area was 377.0 mm². A total of 41 patients were included in the clinical correlation.

Conclusions: FS with a narrow anteroposterior diameter and longer horizontal diameter are difficult to access endoscopically, especially for lesions affecting the lateral recess of the sinus, and may require a combination with an external approach. FS approaches can be selected according to the sinus morphology of each patient, the surgeon's preferences, institutional resources, and the lesion's nature and extension.

KEYWORDS

axillary flap, draf, endoscopic sinus surgery, frontal sinus, osteoplastic flap procedure

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Key points

- *Significant findings of the study:* Frontal sinuses with a narrow anteroposterior diameter and longer horizontal diameter are difficult to access endoscopically, especially for lesions affecting the lateral recess of the sinus, and may require a combination with an external approach.
- *What this study adds:* The study emphasizes the importance of preoperative assessment for each case with frontal sinus lesion, highlighting certain indicators that aid novice ENT surgeons in selecting the most suitable approach for each patient.

INTRODUCTION

Surgical interventions involving the frontal sinus (FS) present a significant challenge due to the anatomical complexities of its outflow tract. The FS is a region of intricate anatomical structure, both in terms of function and morphology. The complex outflow tract follows a posteroinferior direction, laterally bounded by the orbits and medially by the skull base.^{1,2} Notably, the anatomy can vary even between the left and right sides of an individual. Several factors contribute to the demanding nature of approaching FS lesions, including the acute angle from the nostril to the sinus, the medial and superior orbital walls encompassing the nasofrontal outflow tract, and the convex posterior and concave anterior sinus walls. These anatomical constraints limit the width of potential endoscopic frontal sinusotomies and introduce additional complexity, risks, and the possibility of restenosis compared with endoscopic approaches to other sinuses.³⁻⁵

The FS may be affected by various lesions that necessitate an invasive approach. This is particularly common when managing lateral sinus lesions, which encompass a broad spectrum of pathologies including inflammatory and neoplastic diseases, skull base defects associated with meningoencephaloceles, cerebrospinal fluid leaks, and traumatic injuries. Consequently, multiple surgical approaches have been developed to address these lesions, including traditional open techniques as well as endoscopic approaches. These methods aim to achieve effective lesion removal, restore normal sinus drainage, and minimize postoperative complications.^{6,7} Over the past three decades, endoscopic sinus surgery (ESS) has undergone remarkable advancements, enabling the treatment of a wide range of sinonasal tract pathologies. ESS has evolved extensively to encompass the management of conditions spanning from inflammatory chronic rhinosinusitis to skull base pathologies and sinonasal tumors.^{7,8} To address the FS specifically, Draf has described a spectrum of microscopic interventions that were subsequently adapted to endoscopic techniques. These range from performing only a total ethmoidectomy without direct intervention on the frontal recess (Draf I), to complete clearing of the frontal recess (Draf IIa), further removal of the FS floor and middle turbinate (Draf IIb), to an extended sinusotomy that marsupializes the bilateral sinuses through a trans-septal clearing of the

floor and intersinus septum (Draf III or endoscopic modified Lothrop procedure).^{9,10}

Despite advancements in endoscopic-powered instrumentation and image guidance, the variable anatomy of the FS can present insurmountable challenges. Certain anatomical features, such as a narrow frontal recess, type 4 isolated frontal cells, and lesions in the lateral or superoanterior aspects of the FS, may be inaccessible using standard endoscopic instruments.^{11,12} Furthermore, conditions like neo-osteogenesis of the sinus outflow tract, previous trauma, and frontal bone osteomyelitis can be challenging to manage through an endoscopic approach alone. These cases may necessitate combining endoscopic techniques with external approaches, including trephination, frontal sinusotomy via trans-palpebral, trans-caruncular, or Lynch incisions, or even an osteoplastic flap procedure. These and other techniques have been described for the management of FS lesions, with varying degrees of success.¹³⁻¹⁵ Endoscopic approaches offer the advantage of avoiding facial and scalp incisions but are limited by the superior and lateral orbital walls. In contrast, external approaches provide extensive exposure but potentially lead to cutaneous nerve damage or unsightly scars. To leverage the strengths of both methods, combined approaches are increasingly being adopted in clinical practice.¹⁵⁻¹⁷

METHODS

Study design

A descriptive cross-sectional study was carried out based on the endoscopic and external dissections of fresh human cadavers. Both endoscopic endonasal and external approaches to the FS were performed on 15 adult cadaveric specimens (30 sides) which were lightly fixed and prepared for endoscopic dissection at the Anatomy Laboratory Toward Visuospatial Surgical Innovations in Otolaryngology and Neurosurgery (ALT-VISION) at the Wexner Medical Center of The Ohio State University. The common carotid and vertebral arteries of all specimens were isolated and injected with red silicone for the arterial system. All

specimens were stored in 70% alcohol solution for further dissection over the procedure.

The rigid rod-lens endoscopes (4 mm diameter, 18 cm length) with 0°, 30°, and 45° lenses (Karl Storz Endoscopy; Karl Storz) were paired with a high-definition camera and video monitor. Videographic and standard digital images of the dissections were recorded during the dissections using the AIDA recording system (Karl Storz Endoscopy; Karl Storz) which was used for image archiving also. Five screws were placed around the skull of every specimen, and a high-resolution multiplanar thin 1 mm cut computed tomography (CT) scan was performed for every specimen of the 15 heads before the dissection, and the data were exported to a surgical navigation system (Stryker, iNtellect image guidance) to obtain stereotactic measurements of the anatomical field during dissection. Curved and straight sinus instrument set and a high-speed drill (Medtronic) with both straight and curved handpieces and 3- to 4-mm hybrid burrs were used in the dissection. ALT-VISION and its researchers comply with all regulatory agencies pertaining to cadaveric studies.

For the clinical correlation, 41 patients with various FS pathologies, who underwent endoscopic, external, or combined FS surgeries at the Otorhinolaryngology Department, Tanta University Hospitals were enrolled. Permission to perform the study was obtained from the "Ethical Committee for Research" of the Faculty of Medicine, Tanta University, and informed consent to participate in the study was obtained from each patient. Quantitative

measurements of FS, location of the lesions, and the surgical technique used were studied.

Surgical technique

Endoscopic approaches

A stepwise endoscopic endonasal dissection to the FS included an uncinectomy followed by a complete anterior ethmoidectomy (Draf I). Then, the frontonasal recess was opened, clearing all cells from lamina papyracea laterally and opening the recess extending from the orbit laterally to the middle turbinate medially (Draf IIa). This was followed by the removal of the antero-inferior middle turbinate preserving the axilla and removing the sinus floor to reach the nasal septum medially (Draf IIb). In some cadavers, a prebulla (intact bulla) technique was performed to illustrate how to avoid injury of the anterior ethmoid artery. An axillary flap procedure was then completed comprising a posteriorly based mucosal flap as described by Wormald.¹⁸ A Draf III (endoscopic modified Lothrop procedure) was completed after the removal of the middle turbinate bilaterally. A superior septal window was created starting anteriorly at the level of the anterior wall of the FS and extending posteriorly to the level of the first olfactory filament. The frontal beak was drilled along with the interfrontal sinus septum, septations, and sinus floor, creating a wide horse-shoe-shaped opening between the orbits (Figure 1).

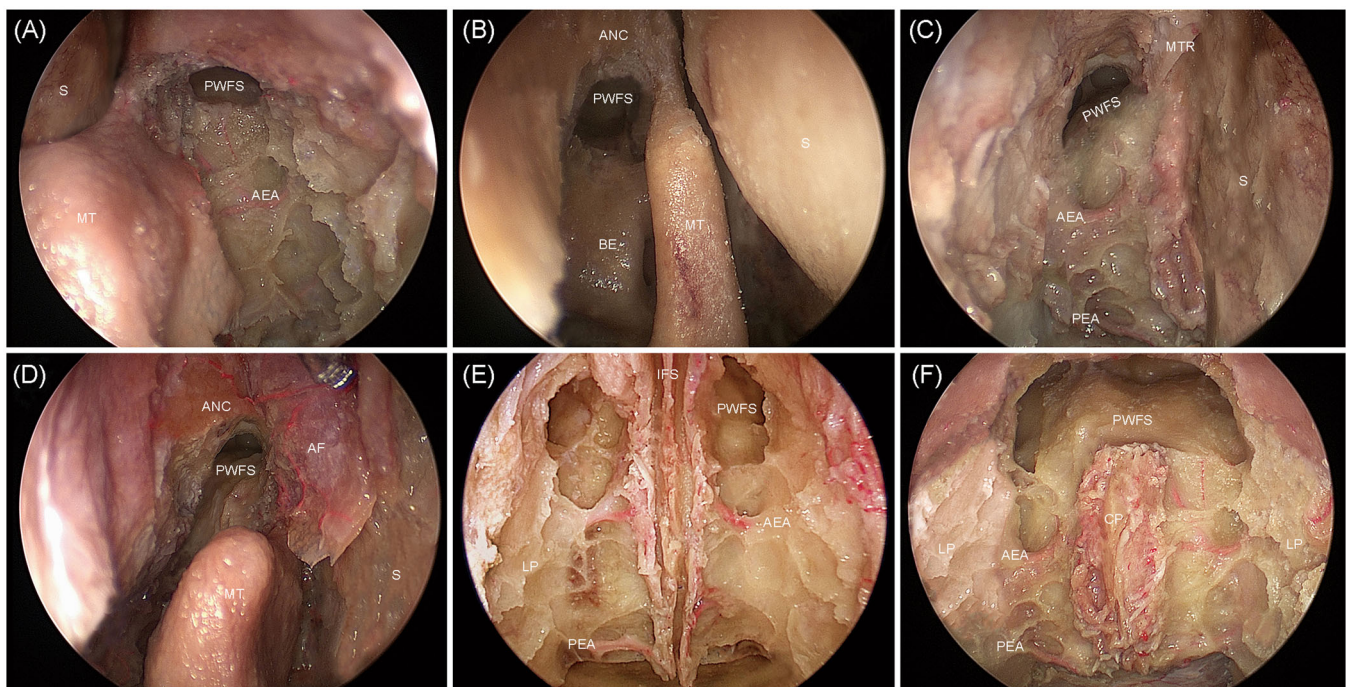


FIGURE 1 Overview of endoscopic endonasal sinusotomies. (A) shows left Draf IIa, (B) shows intact bulla technique on the right side, (C) shows right Draf IIb, (D) shows axillary flap technique on the right side, (E) shows both middle turbinates and superior septum removed as the initial steps for Draf III, (F) shows interfrontal sinus septum removed completing the Draf III. (AF, axillary flap; AEA, anterior ethmoidal artery; ANC, agger nasi cell; BE, bulla ethmoidalis; CP, cribriform plate; IFS, interfrontal septum; LP, lamina papyracea; MTR, middle turbinate remnant; MT, middle turbinate; PWFS, posterior wall frontal sinus; PEA, posterior ethmoidal artery; S, septum).

External approaches

External approaches followed the completion of all endoscopic approaches. A medial mini-trephination involved a 10 mm incision at the superomedial eyebrow. Following the elevation of the periosteum, the anterior table was trephined. A Lynch incision, extending along the lateral nasal dorsum and below the medial eyebrow allowed the removal of the corresponding exposed bone creating a wider drainage. The upper blepharoplasty sinusotomy was performed as described¹⁹ and the lateral wall of the sinus was identified by transillumination from inside the nose and confirmed through the navigation system outlining the sinus boundaries then a trephine was carried out. Drilling burr and subsequent instrumentation were kept in a medial direction to avoid injury of the posterior sinus wall as the anteroposterior diameter decreases gradually toward the lateral recess (Figure 2). An osteoplastic flap procedure was carried out through a bicoronal incision as previously described.²⁰ The outlines of the FS were identified by endoscopic transillumination and confirmed with the image guidance system, then the borders of the anterior walls of the sinus were drilled exposing the entire sinus cavity bilaterally (Figure 3).

Quantitative analysis

Anatomic measurements were calculated and documented using the navigation system. One specimen was transected by the mid-sagittal

plane to demonstrate the anteroposterior diameters of the FS. Indices such as the FS dimensions were measured. The anteroposterior diameter was measured on the midsagittal plane from a midline point over the posterior table of the FS to the frontal beak anteriorly. Horizontal diameters were measured on both sides of the crista galli and interfrontal sinus septum on the same level as a landmark for the midline toward the most lateral point of each sinus on the coronal plane. Interorbital distance, between the two lamina papyracea at the level of the nasolacrimal sac, was also measured in the coronal plane. The pneumatization pattern was divided into two zones; Zone 1 was defined as the area of the FS extending from crista galli to the supraorbital neurovascular bundle (SOB) and Zone 2 as the area extending from SOB to lateral most point of FS on each side (Figure 4).

The area of exposure, obtained with each endoscopic endonasal approach, was calculated using four anatomical points representing the four cardinal directions to the FS ostium and representing maximum visualization points using a 45° endoscope via the ipsilateral nostril. For each of the four points, coordinates were documented in the three axes (x, y, z) using the navigation system. Accordingly, the total area of exposure without manipulation of the endoscope was calculated by the Heron's formula which uses the coordinates to create two imaginary triangles and the sum area of those triangles represents the exposed area. For clinical cases, preoperative FS measurements, including anteroposterior and horizontal diameters, were studied and correlated with lesion location and nature to plan and decide the most suitable surgical procedure.

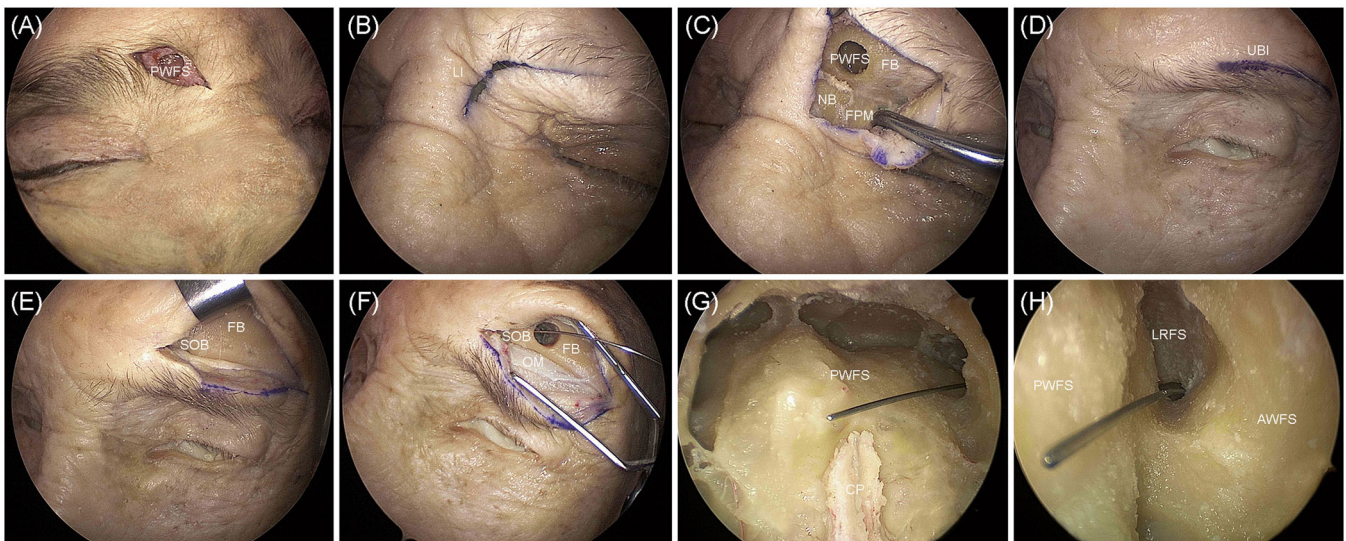


FIGURE 2 External approaches of the frontal sinus. (A) shows right medial mini trephination of the frontal sinus, (B) shows Lynch incision along the medial aspect of left eyebrow and extending over the lateral nasal dorsum, (C) shows frontal bone exposed and drilled after Lynch incision. (D–H) show steps of the left upper blepharoplasty approach: (D) shows the left upper blepharoplasty incision, (E) shows exposure of left frontal bone up to the supraorbital bundle, (F) shows drilled left frontal bone with a probe inserted into the frontal sinus and directed medially, (G) shows the end of the probe with endoscopic endonasal view with previously performed Draf III, (H) shows the same entrance point of same probe from inside the lateral recess of left frontal sinus. (Endoscopic view taken from opposite frontal sinus through medial trephination approach. AWFS, anterior wall frontal sinus; CP, cribriform plate; FB, frontal bone; FPM, frontal process of maxilla; LI, Lynch incision; LRFS, lateral recess frontal sinus; NB, nasal bone; OM, orbicularis muscle; PWFS, posterior wall frontal sinus; SOB, supraorbital bundle; UBI, upper blepharoplasty incision).

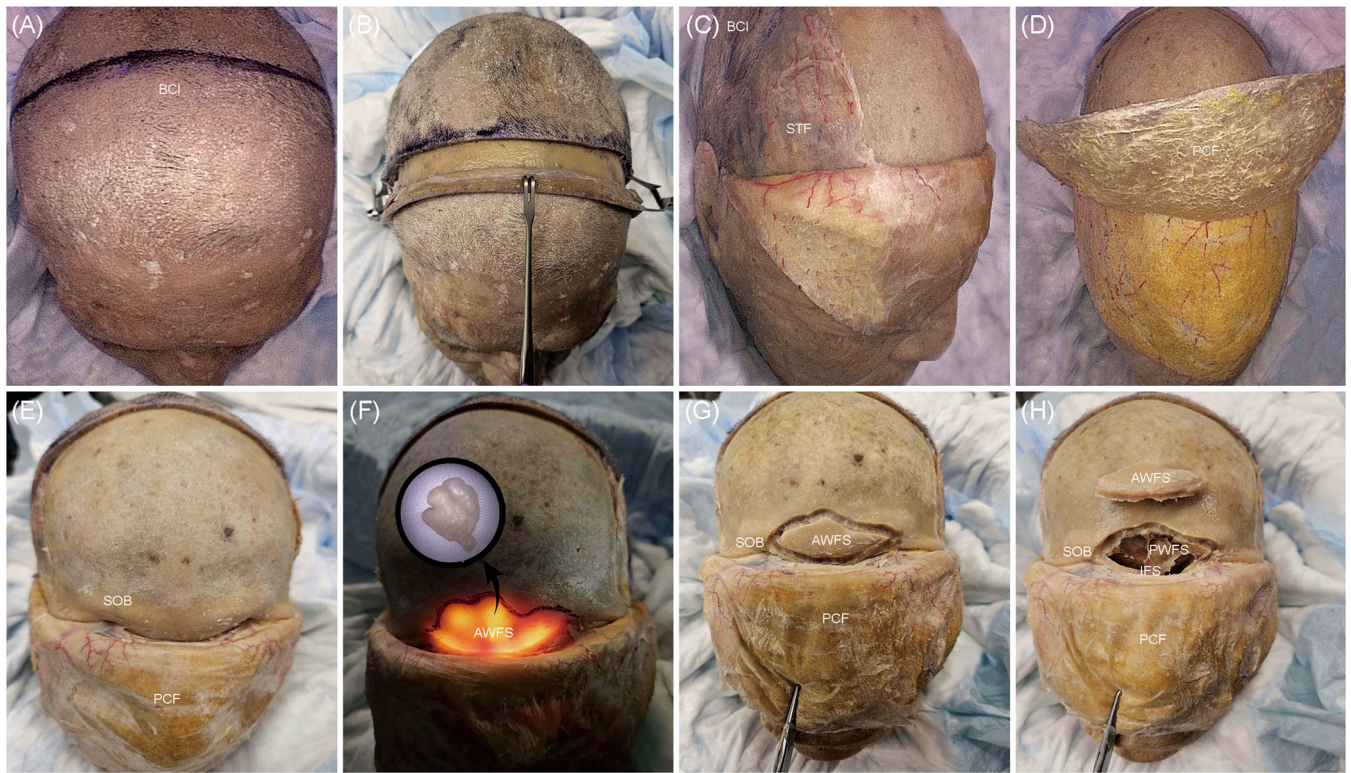


FIGURE 3 Steps of osteoplastic flap procedure. (A–C) show the bicoronal incision and exposure. (D) shows pericranial flap elevation, (E) shows exposure till supraorbital bundle on both sides, (F) shows transillumination outlining the boundaries of the frontal sinus over its anterior table, with the mucosa of the right sinus removed afterward as one piece showing the same outlines, (G) shows drilling along borders of anterior wall of frontal sinus as shown by transillumination, (H) shows anterior wall frontal sinus removed exposing its posterior wall on both sides. (AWFS, anterior wall frontal sinus; BCI, bicoronal incision; PCF, pericranial flap; PWFS, posterior wall frontal sinus; SOB, supraorbital bundle; STF, superficial temporal fascia).

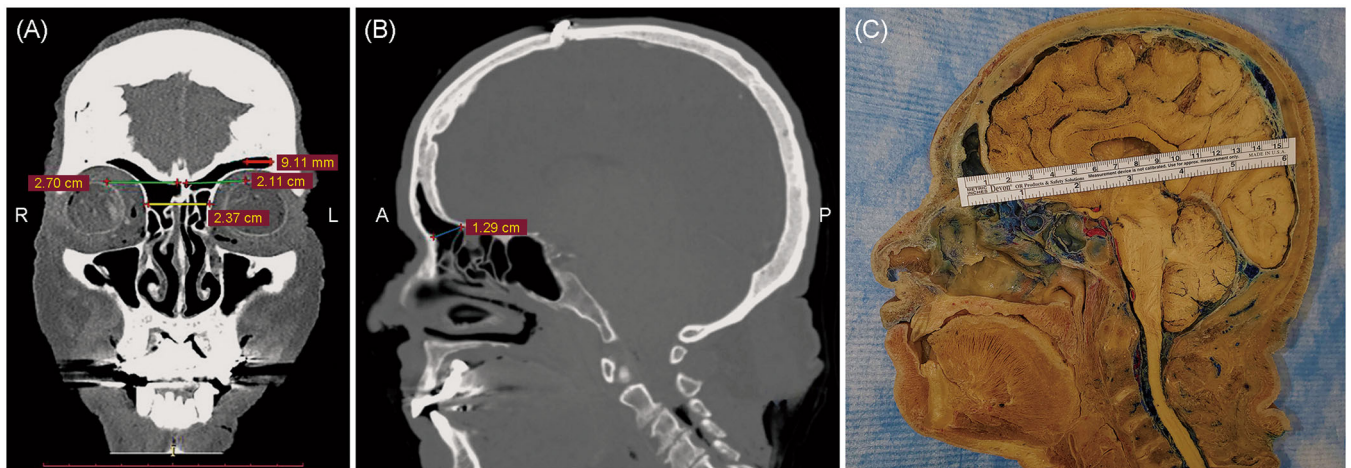


FIGURE 4 Frontal sinus measurements. (A) Coronal computed tomography (CT) scan demonstrating horizontal diameters of the frontal sinus, a green line representing Zone 1 (green line) on both sides extending from midline to supraorbital bundle, and Zone 2 (red line) present only on the left side as well as interorbital distance (yellow line). (B) Sagittal CT scan showing anteroposterior diameter of the frontal sinus (blue line). (C) showing cadaveric head cut at a mid-sagittal plane to show the anteroposterior diameter of the frontal sinus.

Statistical analysis

This study reports the means and standard deviations for variables that are roughly normally distributed in the sample. An analysis of variance (ANOVA) test was employed to compare three or more groups of quantitative variables, with a 5% significance level applied to assess statistical significance for all tests. The statistical analyses were performed using the Jamovi 2.3.26 edition.

RESULTS

Distances

Fifteen cadavers were dissected resulting in the examination of 30 FS on both sides. Five specimens were males (33.33%) and 10 were females (66.67%). The average anteroposterior diameter was (12.30 ± 3.24) mm. The average distance between the lateralmost points (horizontal diameter of both sinuses) was (44.90 ± 15.00) mm, while the average interorbital distance was (24.50 ± 5.24) mm. Moreover, the average distance from the midline to the lateralmost point of the sinus (horizontal diameter of each sinus) on the right side was (21.80 ± 7.52) mm and (23.10 ± 7.75) mm on the left side. The average distance from the midline to the supraorbital bundle (Zone 1) was (13.40 ± 3.56) mm and (13.10 ± 3.94) mm on the right and left sides, respectively. The average distance between the supraorbital bundle and the lateralmost point of the FS (Zone 2) was (4.24 ± 1.05) mm on the right side and (5.59 ± 2.46) mm on the left side.

Area of exposure

The mean areas of exposure on the right side for Draf IIa, Draf IIb, and axillary flap were (64.6 ± 24.0) mm², (115.0 ± 19.7) mm², and (143.0 ± 37.0) mm², respectively ($p \leq 0.001$). Similarly, on the left side, the mean areas of exposure for the Draf IIa, Draf IIb, and axillary flap measured (67.0 ± 24.0) mm², (125.0 ± 24.9) mm², and (145.0 ± 31.5) mm², respectively. ($p \leq 0.001$). The area of the FS exposed for the Draf III was (377.0 ± 74.7) mm².

Patients' demographics, clinical presentation, and diagnosis

Forty-one patients were included in the study. The average age was 40.6 years, and 68.3% of them were males. At presentation, they all experienced frontal headaches ($n = 41$, 100.00%), nasal obstruction (32, 88%), and eye symptoms including pain, pressure, or diplopia (11, 26.80%). Patients were diagnosed with chronic bacterial rhinosinusitis (19, 46.34%), chronic invasive fungal rhinosinusitis (5, 12.19%) fracture of the anterior wall of FS (4, 9.76%), frontoethmoidal mucocele (4, 9.76%), allergic fungal rhinosinusitis (3, 7.32%), frontal osteoma (3, 7.32%), and inverted papilloma (3, 7.32%).

FS lesions, zones affected, and operation performed

Lesions were limited only to Zone 1 in 17 patients (41.5%), Zone 2 only in one patient (2.4%), and extended to Zones 1 and 2 in 23 patients (56.1%). FS pathologies, zones affected, and operation performed was highlighted in Table 1. Draf IIa, Draf IIb, and Draf III were performed in 13 (31.7%), 12 (29.3%), and 1 (2.4%) patients, respectively, while an axillary flap procedure was carried out in one patient (2.4%). Osteoplastic flap procedures were carried out in 13 patients (31.7%) while a combined Lynch approach—Draf IIa was performed in one patient. Recurrence was detected in five patients (12.5%). Among these, four patients had chronic frontal rhinosinusitis, while one patient had allergic fungal rhinosinusitis. The average preoperative and 3-month postoperative sino-nasal outcome test (SNOT) 22 scores were 53.3 and 25.7, respectively (Table 2).

Illustrative cases

Case 1

A 45-year-old woman presented with a chronic right frontal headache of 3 months duration. CT scans showed isolated FS opacity on the right side and the patient was diagnosed as isolated chronic frontal rhinosinusitis. The lesion was confined to Zone 1 of FS. The distance from the midline to the lateralmost point of the right sinus was 18.45 mm while the anteroposterior diameter measured 13.32 mm. Endoscopic endonasal frontal sinusotomy with Draf IIa was performed and the postoperative follow-up period was uneventful.

Case 2

A 29-year-old man presented with painful tender swelling and hematoma of the forehead after blunt trauma to the head. CT scan revealed multiple fracture lines along the anterior table of the FS with hem sinus while the posterior wall was intact. Both Zones 1,2 of FS were affected, and a full exposure of the anterior table of FS was required. Subsequently, an osteoplastic flap procedure was planned, and a titanium mesh was used for the reconstruction of the sinus anterior table. The patient was followed up for 6 months with no complications.

Case 3

A 47-year-old man presented with tender swelling of 10-day-duration superomedial to left orbit. A CT scan showed total opacification of the left FS with rarefaction and destruction of the sinus floor. The sinus anteroposterior diameter measured 10.03 mm while the distance from the midline to the lateralmost point of the sinus lateral recess was 25.31 mm. Magnetic resonance (MR) imaging

TABLE 1 Patients' lesions distribution over frontal sinuses zones and the performed operation (n = 41).

Frontal sinus lesion type	Frontal sinus zone affected	Operation type
Chronic bacterial rhinosinusitis (n = 19, 46.34%)	11 in Zone 1	8 Draf IIa, 3 Draf IIb
	1 in Zone 2	1 Axillary flap
	7 in Zones 1 and 2	2 Draf IIa, 5 Draf IIb
Chronic invasive fungal rhinosinusitis (n = 5, 12.19%)	5 in Zones 1 and 2	5 osteoplastic flap procedure
Fracture anterior table frontal sinus (n = 4, 9.76%)	4 in Zones 1 and 2	4 osteoplastic flap procedure
Frontoethmoidal mucocele (n = 4, 9.76%)	2 in Zone 1	1 Draf IIb, 1 combined Draf IIa with Lynch incision
	2 in Zones 1 and 2	1 Draf IIb, 1 Draf III
Allergic fungal rhinosinusitis (n = 3, 7.32%)	2 in Zone 1	3 Draf IIa
	1 in Zones 1 and 2	
Frontal osteoma (n = 3, 7.32%)	3 in Zones 1 and 2	3 osteoplastic flap procedure
Inverted papilloma (n = 3, 7.32%)	1 in Zone 1	1 Draf IIb
	2 in Zones 1 and 2	1 Draf IIb, 1 osteoplastic flap procedure

TABLE 2 Clinical characteristics for patients with frontal sinus lesions (n = 41).

Clinical characteristics		Value
Sex [n (%)]	Male	28 (68.3)
	Female	13 (31.7)
Age (years, Mean ± SD)		40.6 ± 12.6
Presenting symptom [n (%)]	Headache	41 (100.0)
	Nasal obstruction	32 (88.0)
	Eye symptoms	11 (26.8)
Site of frontal sinus lesions [n (%)]	Zone 1	17 (41.5)
	Zone 2	1 (2.4)
	Zone 1 and 2	23 (56.1)
Operation type [n (%)]	Draf IIa	13 (31.7)
	Draf IIb	12 (29.3)
	Draf III	1 (2.4)
	Axillary flap	1 (2.4)
	Osteoplastic flap procedure	13 (31.7)
	Combined (Draf IIa with Lynch)	1 (2.4)
Recurrence [n (%)] ^a	Yes	5 (12.2)
	No	35 (85.4)
Preoperative SNOT 22 (Mean ± SD) ^a		53.3 ± 12.5
3 month Postoperative SNOT 22 (Mean ± SD) ^a		25.7 ± 9.3

Abbreviation: SNOT, sino-nasal outcome test.

^aOne patient was lost during the postoperative follow-up.

showed a circumscribed lesion within the FS extending to the ethmoid region with an isointense signal on T1 weighted images and hyperintense signal on T2 weighted images and the patient was diagnosed with frontoethmoid mucocele. The mucocele occupied Zone 1 of FS. Because of the relatively narrow anteroposterior diameter, wide horizontal diameter of the FS, complete access of the mucocele was not achievable endoscopically, and a combined multiportal approach was required. Moreover, the outflow tract showed extensive osteogenesis, and the lesion extended toward the lateral recess of the FS, so Draf IIa was combined with an external Lynch incision and a trephine was drilled in the anterior table of the FS for full exposure and complete drainage. Three and 6-month-follow ups showed complete recovery without complications (Figure 5).

DISCUSSION

The ability to predict which areas of the FS are accessible endoscopically and those that might require external approaches is important for preoperative planning and ultimately for patient outcomes. Moreover, the site of attachment of certain lesions can be deduced by areas of hyperostosis within the sinus which needs to be accessible to be removed using powered instrumentation to avoid a recurrence.^{11,13} Our study emphasizes select predictive measurements and indices that evaluate the feasibility of different endoscopic and external approaches to various areas of the FS to guide entry-level surgeons through better preoperative assessment, especially for areas that are considered relatively hard to reach, such as the lateral and anterior walls.

Measurements on the sagittal plane included the anteroposterior diameter, which affects the surgical freedom and

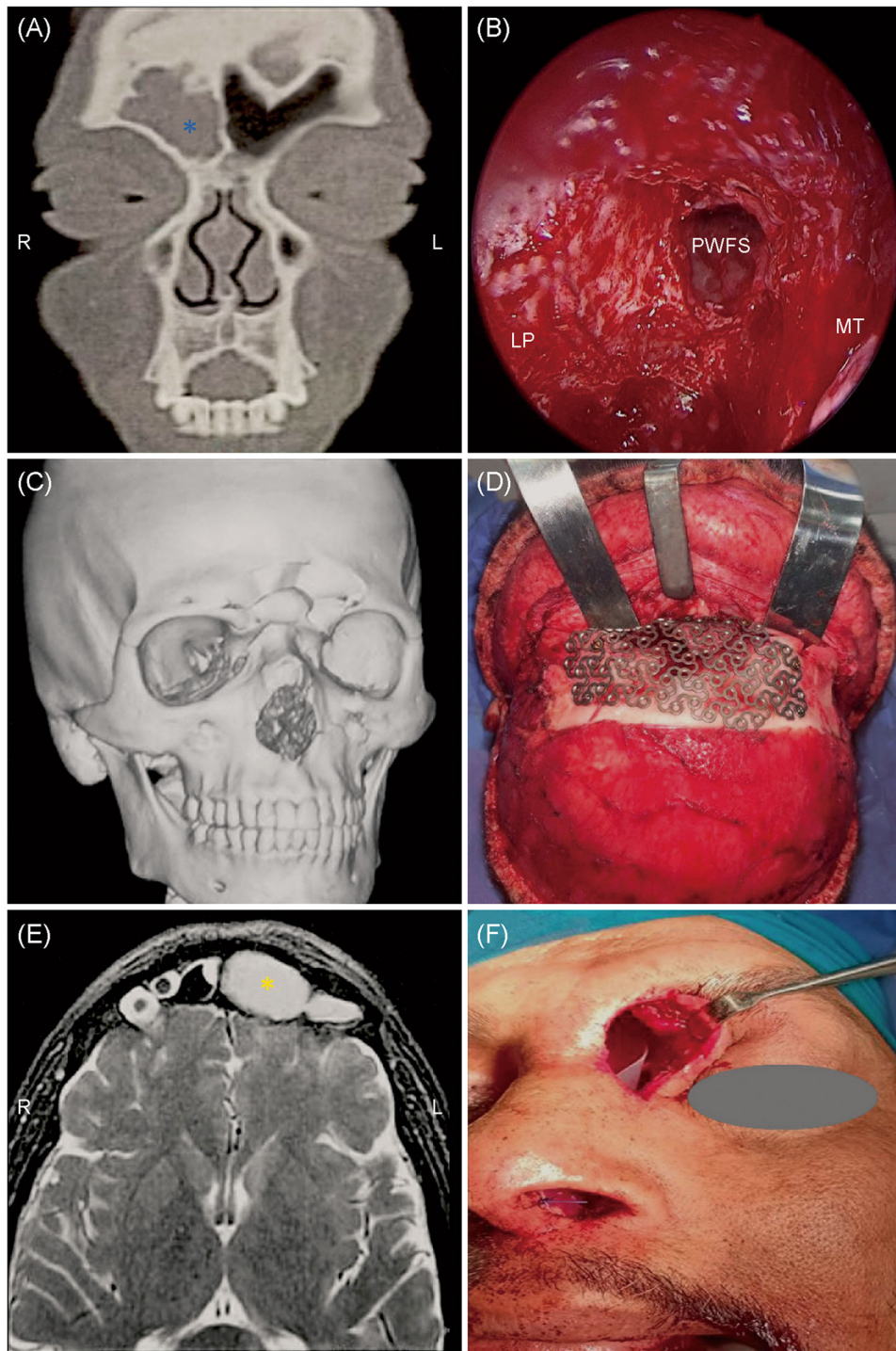


FIGURE 5 (A–B) show Case 1 with frontal sinus lesion: (A) computed tomography (CT) scan showing opacification of right frontal sinus indicating isolated right frontal sinusitis marked with a blue asterisk, (B) endoscopic endonasal view showing right Draf IIa. (C–D) show Case 2 with frontal sinus lesion: (C) three-dimensional (3D) CT reconstruction showing multiple fracture lines in the anterior table of frontal sinus, (D) osteoplastic flap procedure performed to the case with reconstruction of anterior table frontal sinus with titanium mesh. (E–F) show Case 3 with frontal sinus lesion: (E) Magnetic resonance imaging (MRI) T2 weighted image showing total opacification of left frontal sinus with extension to the lateral recess of the sinus (yellow asterisk), (F) combined endoscopic endonasal Draf IIa was performed with external Lynch incision and a silastic sheet was fixed along the frontal sinus drainage pathway to preserve patency.

maneuverability of the instrument. Moreover, in patients with narrow anteroposterior diameters, Draf III is not recommended. Measurements on the coronal plane included distance from the midline to the supraorbital notch, interorbital distance, and distance from the midline to the lateralmost point. These coronal indices indicate the potential reach of straight and curved instruments within the FS, especially toward the lateral recess and anterior wall. Generally, Zone 1 (extending from midline to the level of the supraorbital bundle) was accessible by Draf II and axillary flap technique, while Zone 2 (extending laterally beyond the level of the supraorbital bundle) required a Draf III to acquire the angulation needed to address that area. In brief, wider interorbital distance and larger anteroposterior diameter allow more space and maneuverability to address the lateral recess and anterior wall of the sinus.

In the first case mentioned above, the relatively wide anteroposterior and small horizontal FS diameters facilitated complete access and drainage. On the other hand, the narrow anteroposterior and large horizontal diameters of the third case limited the adequate evacuation of the frontoethmoidal mucocele, which extended through the lateral recess of the FS, raising the need for a combination with an external Lynch incision and FS trephination to access the most lateral areas of the sinus.

Several studies have identified metrics that help to select the most appropriate approach. Timperley et al.²¹ studied the lateral reach of endoscopic approaches within the FS using CT scan measurements such as the thickness of the nasofrontal beak, and distances from midline to midorbital points. These authors concluded that lesions medial to the supraorbital bundle can be accessed endoscopically while lesions attached beyond that point cannot be reliably accessed endoscopically and require adjunctive external techniques. Additionally, Becker et al.¹² evaluated the extent of reach and visualization to the FS after Draf IIa, 2b, and 3 and concluded that Draf III can expand the lateral extent of the endoscopic approach. Some studies have introduced modifications to the Draf III technique to include medial and supraorbital decompression with orbital transposition inferolaterally to get even wider access and more surgical freedom than the traditional Draf III approach.^{22,23} A study by Wormald introduced the use of the axillary flap technique in sinus exposure and concluded that it allows access to Zone 2 of the FS using a 30° scope.¹⁸

Another study evaluated the FS reach using the upper blepharoplasty approach to the lateral recess and indicated that it provided excellent access to the FS lateral compartment (Zone 2) and the upper blepharoplasty sinusotomy was an excellent adjunct with the Draf procedures for the reach of all sinus walls with improved surgical maneuverability.¹⁹ Other studies have also demonstrated the improvement in sinus access with a combination of Draf III and Lynch procedure for exposure of the lateralmost areas.²⁴ In addition, the combination of trephination with endoscopic techniques, known as the “above and below” approach was also proposed for better exposure and enhanced surgical freedom.¹³

CONCLUSION

We concluded that lesions extending laterally within the FS beyond a line passing through the supraorbital bundle often require more invasive endoscopic endonasal or external approaches. Furthermore, FS with a narrow anteroposterior dimension and a wide horizontal dimension, particularly with lateral recesses, present significant challenges for endoscopic access, especially when lesions are located laterally. As endoscopic and external approaches of FS are complementary, neither one can substitute the other. Each approach offers viable solutions for lesion removal and restoration of sinus drainage and each has its indications, advantages, disadvantages, and potential complications. The selection of the surgical approach depends on various factors, including the size, the location, the attachment of the lesion, the extent of disease invasion of surrounding structures, patient characteristics, the surgeon's experience, and available resources.

AUTHOR CONTRIBUTIONS

Moataz D. Abouammo: Conceptualization; cadaveric dissections; data collection; and manuscript writing. **Hossam S. Elsherif:** Data collection; review and revision. **Medhat M.H. Mansour:** Data collection; review and revision. **Magdy E. Saafan:** Data collection; review and revision. **Ricardo L. Carrau:** Supervision; resources; review and revision. **Mahmoud F. Abdelaziz:** Supervision; resources; review and revision.

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CONFLICT OF INTEREST STATEMENT

The authors declare no conflict of interest.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available from the corresponding author upon reasonable request.

ETHICS STATEMENT

The study was conducted according to the guidelines of the Declaration of Helsinki; the anatomical part of the study received an exemption from the Institutional Review Board of The Ohio State University and Wexner Medical Center as the cadavers dissected were de-identified, while the clinical part of the study received approval from the Research Ethics Committee of Tanta University (No. 34722/5/21).

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