



RESEARCH

Assessment of dural invasion in complex cases operated on by collaborative efforts of neurosurgery and otolaryngology for pathologies associated with the frontal sinus

Beyin cerrahisi ve kulak burun boğaz hastalıklarının işbirliğiyle opere edilen komplike frontal sinüs patolojilerinde dural invazyonun değerlendirilmesi

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Abstract

Purpose: The aim of this study was to evaluate the common interventions performed by neurosurgery and otolaryngology in dural invasion in frontal sinus related pathologies.

Materials and Methods: A comprehensive study involving 45 patients who underwent surgical interventions for frontal sinus-associated pathologies between January 2018 and July 2023 was conducted collaboratively by otorhinolaryngology and neurosurgery departments. Patient data, including demographics, pathology types, and surgical approaches, were collected from medical records, surgical reports, imaging studies, and videos. Interdisciplinary surgical teams executed tailored interventions with documented techniques.

Results: Among 45 patients, 31 were female (68.8%) with a mean age of 44. Posterior wall defects were detected in 13 (28.8%) patients, and intervention was necessary for only 8 of them. Among the 8 (17.7%) patients with identified dural invasion, pathological dural tissue was excised, and duraplasty was performed in 5 (11.1%) cases. There were no neurological complications observed in patients during the postoperative period.

Conclusion: Despite limitations, the findings contribute to evolving knowledge and highlight the need for prospective studies to optimize patient care strategies.

Keywords: Dural invasion, frontal sinus, otolaryngology, neurosurgery, interdisciplinary collaboration

Öz

Amaç: Bu çalışmada frontal sinüsle ilişkili patolojilerde dural invazyonun beyin cerrahi ve kulak burun boğaz tarafından yapılan ortak müdahalelerin değerlendirilmesi amaçlanmıştır.

Gereç ve Yöntem: Ocak 2018 ile Temmuz 2023 tarihleri arasında frontal sinüsle ilişkili patolojiler için Kulak Burun Boğaz Hastalıkları ve Beyin Cerrahisi bölümleri tarafından işbirliğiyle cerrahi uygulanan 45 hasta üzerinde kapsamlı bir çalışma yapıldı. Hastaların demografik bilgileri, patoloji türleri ve cerrahi yaklaşımları; tıbbi kayıtlardan, cerrahi raporlardan, görüntüleme çalışmalarından ve videolardan toplandı. Cerrahi tercih kararları patolojiye özel verildi ve uygulanan teknikler kayıt altına alındı.

Bulgular: 45 hastanın 31'i kadın (%68,8) olup yaş ortalaması 44'tür. Cerrahi sırasında arka duvar defekti 13 (%28,8) hastada tespit edilmiş olup sadece 8'ine müdahale gerekti. Tanımlanan dural invazyonu olan 8 (%17,7) hastada ise 5 (%11,1) vakada patolojik dural doku çıkarıldı ve duraplasti yapıldı. Hastalarda postoperatif dönemde nörolojik komplikasyon gözlenmedi.

Sonuç: Sınırlamalara rağmen, bulgular gelişen literatüre katkıda bulunurken, hasta değerlendirme stratejilerini optimize etmek için ileriye yönelik çalışmalara ihtiyaç olduğunu da vurgulamaktadır.

Anahtar kelimeler: Dural tutulum, frontal sinüs, intrakraniyal komplikasyonlar, kulak burun boğaz, nöroşürji, disiplinler arası işbirliği

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INTRODUCTION

Pathologies associated with the frontal sinus encompass a wide range of conditions, from benign to malignant tumors to infections¹⁻². Many of these pathologies remain confined within the frontal sinus and can be easily treated with endoscopic sinus surgery in today's medical practice³⁻⁵. However, infections and malignant tumors, particularly due to their aggressive nature, can easily extend beyond the posterior wall of the sinus into the intracranial or intraorbital space. In such cases, the complications they can generate can pose significant challenges for monitoring and treatment.

In complex cases like these, preoperative MRI and CT scans play a crucial role in surgical outcomes⁶⁻⁷. These investigations provide valuable information for selecting the appropriate surgical approach by revealing factors such as breach of sinus posterior wall, dural invasion, and intracranial extension. Especially when dural involvement is suspected, and surgical resection of the dura and duraplasty are deemed necessary, the rates of surgical difficulty and postoperative complications increase⁸.

The anatomical proximity of the frontal sinus to critical intracranial structures necessitates meticulous attention to the potential for dural invasion or involvement, which can significantly influence treatment decisions and surgical planning⁹⁻¹³. The management of these complex cases may pose significant challenges for otorhinolaryngologists. In such scenarios, seeking the assistance of a neurosurgeon experienced in these pathologies becomes inevitable. Ideally, complex cases of this nature should undergo preoperative evaluation and treatment planning through a collaborative effort between both specialties, culminating in a joint decision-making process. While encounters with such cases may be relatively rare, we believe that the synergy between these two disciplines can yield substantial benefits for both patients and healthcare providers. In line with this approach, over the past five years, our otorhinolaryngology and neurosurgery departments have jointly evaluated and managed cases involving lesions associated with the posterior wall of the frontal sinus or those posing a threat further posteriorly.

In this study, we share our experiences, focusing on the short-term surgical outcomes, intraoperative observations of posterior sinus wall involvement, dural interactions, and intracranial extensions, along

with our treatment choices in such cases. Furthermore, we aim to underscore the positive impact of this collaborative approach on the quality of surgical interventions and outcomes, as well as its contributions to our mutual education in regional anatomy and surgery.

MATERIALS AND METHODS

Study design and participants

This study was conducted at the Health Sciences University Antalya Training and Research Hospital, which is a tertiary care facility. Between January 2018 and July 2023, a total of 267 patients who underwent surgery due to paranasal sinus pathologies were retrospectively evaluated. Out of these cases, 45 were included in the study, which focused on pathologies related to the frontal sinus. Cases involving frontal sinus masses due to nasal polyps (n=31), nasal polyps with sinusitis in other paranasal sinuses (n=81), benign and malignant tumors originating from other paranasal sinuses (n=22), mycetomas (n=52), foreign bodies (n=18), mucormycosis cases (n=9), and pediatric cases (n=9) were excluded from the study.

We secured ethical approval from the institutional review board (Health Sciences University Antalya Training and Research Hospital Clinical Research Ethics Committee, Approval Number and date: 11/25, 24/08/2023). Informed consent was waived due to the retrospective nature of the study.

Data collection

Patient data, including demographic information, medical history, radiological images, surgical procedures, and outcomes, were collected from electronic medical records and surgical reports. To ensure accuracy, we regularly reviewed and verified the collected data. To enhance data reliability, we conducted an inter-rater reliability assessment by having two independent experts evaluate the data separately.

Preoperative evaluation

All patients underwent preoperative endoscopic examination conducted by the otorhinolaryngology team. Also contrast-enhanced/non-contrast cranial magnetic resonance imaging (MRI) as well as paranasal sinus computed tomography (CT) scans were performed.

Surgical procedures

All cases were performed by two senior surgeons, one of whom was an otorhinolaryngologist and the other a neurosurgeon. Both surgeons had a minimum of 10 years of experience in the specific pathologies mentioned in the study. The surgeries were conducted in the otorhinolaryngology operating room. In all cases, the neurosurgeon was present in the operating room. In the event of dural and/or intracranial involvement being observed, the neurosurgeon actively participated in the surgery. Tailored to each patient's unique condition, these procedures were carefully conducted to address the specific pathology.

A wide incision was made along the tissue border where dural involvement was suspected, while preserving healthy tissue. Galeal graft and fibrin glue were used for duraplasty. Lumbar drainage was not required.

Statistical analysis

Considering the numerical limitations of our study, we aimed to conduct data analysis through visual examination of the data, creating tables, summarizing the data, and drawing certain conclusions with explanations, instead of utilizing statistical methods. While this approach may have certain drawbacks,

such as potentially affecting the reliability of the study's data, its generalizability, and the ability to make data comparisons, we believe it has provided some insights that can serve as clues for future research.

RESULTS

A total of 45 patients who underwent surgical intervention for pathologies associated with the frontal sinus between January 2018 and July 2023 were retrospectively evaluated. Of these patients, 31 were female (68.8%), and the mean age was 44 years (range, 32–61).

An investigation of posterior wall damage and the presence of dural invasion were conducted. If dural invasion was present, additional surgeries performed (dural excision, duraplasty) were documented (Table 1). In the preoperative paranasal sinus computerized tomography images, sinus posterior wall defects were detected in 13 (28.8%) patients. However, during the intraoperative assessment, only eight (17.7%) of them showed dural invasion, and out of these, dural excision and duraplasty were performed in only five (11.1%) cases. Additionally, in two cases with brain abscess, craniotomy was required for drainage of the abscess within the brain parenchyma.

Table 1. Dural involvement of the lesions (SCC: Squamous cell carcinoma)

Pathology	Number of Patients	Posterior wall defect	Dural involvement	Dural excision	Duraplasty
Osteoma	20	3	-	-	-
Fibrous dysplasia	2	2*	-	-	-
Mucocele	15	-	-	-	-
Brain abscess	2	2	2	2	2
SCC	1	1	1	1	1
Inverted papilloma	4	4	4	1	1
Meningioma	1	1	1	1	1
Total	45	13	8	5	5

* Defects developed post-surgery; however, no repair was necessary.

In none of the cases where duraplasty was performed, postoperative cerebrospinal fluid leakage occurred. Additionally, there were no postoperative wound infections or instances of meningitis observed in these patients.

Patients were discharged after an average of 3 days postoperatively. Only the two patients with brain abscesses received intravenous antibiotic treatment

for several weeks in the neurosurgery department before being discharged with oral antibiotics.

The surgical approaches were stratified based on the identified pathologies, and the findings are presented below:

Osteoma: Osteomas were detected in 20 patients, with 4 undergoing a bicoronal approach and 16 treated through an eyebrow incision approach.

Recurrence was observed in only one patient. No patient required obliteration procedures. The pathology was unilateral in the majority except for two cases, which were bilateral. Furthermore, three patients exhibited posterior wall defects; however, no repair was needed (Figure 1).

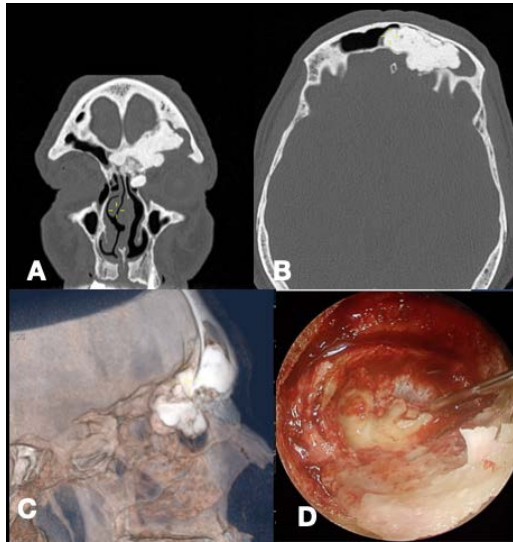


Figure 1. Coronal (A), axial (B), and 3D Computed tomography (CT) images of the patient diagnosed with osteoma, along with the endoscopic view of the tumor (D).

Mucocele: Mucoceles were diagnosed in 15 patients, with no cases of posterior wall defects. Among these, one patient had a history of prior endoscopic sinus surgery and required an osteoplastic, oblitative, eyebrow incision approach due to recurrence. One patient underwent a unilateral eye brow incision approach with obliteration; another patient received a unilateral bicoronal approach without obliteration; and one patient underwent a unilateral eye brow incision without obliteration. The remaining 11 patients were managed solely through endoscopic procedures.

Fibrous Dysplasia: Two patients were diagnosed with fibrous dysplasia, and both underwent an osteoplastic approach. During surgery, posterior wall defects occurred in both cases but did not necessitate repair.

Meningioma: Meningioma was identified in one patient. Surgical intervention involved an osteoplastic approach with an eyebrow incision, revealing dural involvement intraoperatively. Dural tissue was excised, and duraplasty was performed (Figure 2).

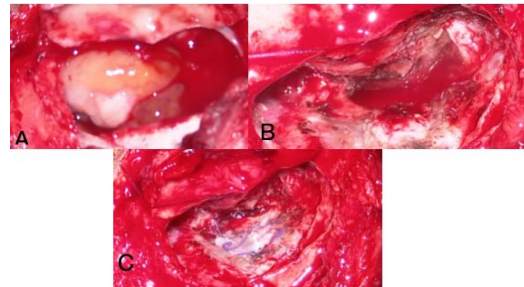


Figure 2. Images before tumor removal (A), before dural repair (B), and after duraplasty (C) in a patient diagnosed with meningioma.

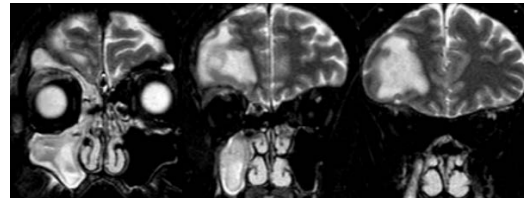


Figure 3. Sagittal T2 coronal section images of a patient with a brain abscess detected in the right frontal region.

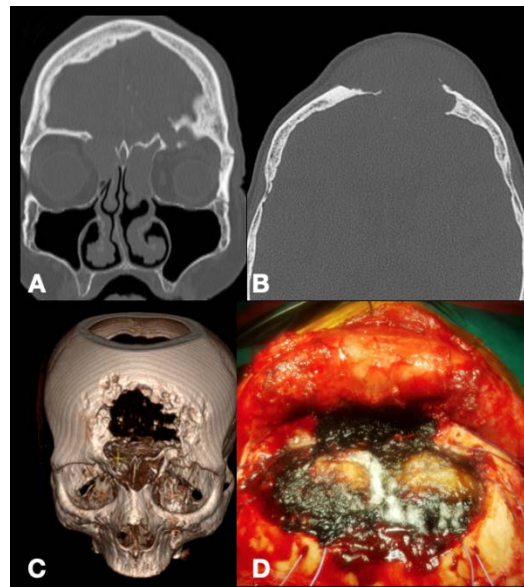


Figure 4. Preoperative coronal (A), axial (B), and 3D computed tomography (C) images of a patient diagnosed with inverted papilloma, along with the macroscopic view after tumor and attached dura were removed and duraplasty was performed (D).

Brain Abscess: A brain abscess was observed in 2 patients, presumed to have developed due to frontal sinusitis. A cranial osteotomy was performed, abscess

drainage was conducted, and the frontal sinus was obliterated (Figure 3).

Inverted Papilloma: Inverted papillomas were diagnosed in 4 patients. Two patients were managed using the osteoplastic approach, with one requiring duraplasty. The other two patients were treated endoscopically without duraplasty (Figure 4).

Squamous Cell Carcinoma: Squamous cell carcinoma was identified in one patient. Open surgery was performed on the patient. Upon detecting dural invasion, the pathological tissue was excised, and duraplasty was carried out using galeal fascia graft and fibrin glue.

DISCUSSION

The collaborative surgical interventions involving the otorhinolaryngology and neurosurgery departments for complex frontal sinus-related pathologies exemplify the significance of interdisciplinary teamwork in managing complex cases. This comprehensive study aimed to explore the implications of dural invasion or involvement within this collaborative framework. In the literature, there are articles reporting that neurologic complications of paranasal sinus surgery such as dural injury and CSF fistula can be repaired by otorhinolaryngologists using endoscopic approaches.¹⁴⁻¹⁷ However, the challenge arises especially for an otorhinolaryngologist when dealing with pathologies extending intracranially or into brain parenchyma. The evaluation of such a patient by both specialties preoperatively and the collaborative surgical intervention by both branches undoubtedly enhance the effectiveness of the procedure and reduce the likelihood of postoperative neurological complications. In our experience, out of a total of 45 collaboratively performed surgeries, dural invasion was observed in only eight cases. Among these cases, dural excision followed by duraplasty was performed in five instances. Apart from cases of brain abscess, no parenchymal pathology was detected. Consequently, there was a need for neurosurgical involvement in a total of 5 (11.1%) cases. Neurological complications such as CSF fistula and meningitis did not occur in these cases during the postoperative period. These findings suggest that collaboration is needed more in cases where dural repair is challenging or when intracranial spread is observed, rather than in every case where dural invasion is suspected.

Indications for frontal sinus surgery include chronic sinusitis that does not improve with maximum medical treatment, the presence of polyps and allergic fungal sinusitis, intracranial complications related to frontal sinusitis, mucocoeles or mucopyocoeles, benign neoplasms like osteomas and inverting papillomas, as well as malignant tumors occurring in the frontal sinus, anterior cranial base, or superior nasal cavity.¹⁸ On the other hand, the indications for open frontal sinus surgery include defects in the anterior wall, lesions with lateral localization, stenosis of the frontal recess area, intracranial spread, orbital spread, and associated complications, as well as benign and malignant tumors located in the frontal sinus, anterior cranial base, or superior nasal cavity.¹⁹ However, in recent years, advancements in endoscopic sinus surgery have made it possible to address much pathology that was previously considered indications for open surgery using endoscopic techniques. The surgeon's experience and the availability of surgical equipment and tools (such as navigation) are also important factors determining the approach. In our surgical preferences, we initially prioritize the endoscopic approach. However, in cases where we anticipate potential difficulties in management, we either opt for open surgery right from the beginning or choose open surgery after attempting the endoscopic approach first.

In a study conducted by Schur and colleagues in 2022, evaluating sinonasal cancers with skull base involvement and intracranial extension, dural invasion was detected in 48.9% of cases, and it was found to be directly proportional to disease progression and mortality²⁰. It was also noted that minor and major complications may be higher in such cases. We indeed observed that in cases with dural involvement and a more aggressive course, the removal of the pathological tissue and repair of the extensive defect were more challenging compared to other cases. In these cases, the presence of an experienced neurosurgeon, in particular, helped us overcome the surgical difficulties.

In a 2019 review article discussing intracranial complications of frontal sinus infections, a total of 16 articles were examined, and these complications were listed in order of frequency as follows: epidural abscess, subdural empyema, meningitis, cerebral abscess, superior sagittal sinus thrombosis, cavernous sinus thrombosis, and bone erosions¹³. Furthermore, the study emphasized that for such life-threatening cases, the most appropriate treatment modality is a

collaborative approach involving endoscopic sinus surgery and neurosurgery.

Osteomas represent the most prevalent type of benign skull tumor. They have a benign nature, but growths can exert compression on adjacent structures and block sinus passages. It has been reported that intracranial growths can lead to significant neurological complications²¹⁻²². In our series, they managed successfully through either bicoronal or eyebrow incision approaches. The low recurrence rate emphasizes the effectiveness of these surgical strategies. Interestingly, bilateral involvement and posterior wall defects were observed in a subset of cases, suggesting potential anatomical variations that warrant further investigation and possible repair considerations.

Mucocele, often presenting intricate challenges, demonstrated diverse management approaches²³⁻²⁴. Although mucoceles are initially described as sterile lesions, when they become infected and transform into mucopyoceles, they give rise to much more serious problems. In a significant portion of our cases, we were able to achieve successful outcomes solely through endoscopic procedures. Having observed no instances of sinus posterior wall defects in any case, except for the necessity of obliteration in only 2 patients, has been a significant factor in reducing the challenges posed by the cases.

Fibrous dysplasia in the frontal sinus is a rare benign condition, but albeit uncommonly, it has the potential to malignantly transform. It predominantly manifests in childhood and evolves into symptomatic stages in later years. The treatment objective is the radical resection of the mass²⁵. In the two cases we encountered, we performed total resection using osteoplastic surgery. Post-surgery, both cases exhibited defects in the posterior wall of the sinus; however, they did not require repair.

In cases of brain abscess, inverted papilloma, and SCC, dural invasion or involvement was observed in all instances. A brain abscess is commonly believed to develop primarily through direct spread via proximity, often originating from frontal sinusitis²⁶⁻²⁷. Once it reaches the subdural space, there are no barriers ahead, allowing easy dissemination onto the cerebral hemisphere surface and complicating the condition²⁸. In both of our cases, patients exhibited mild symptoms such as headaches and nausea. Imaging showed a late cerebritis-early capsule-stage abscess appearance, characterized by prominent

contrast enhancement and perilesional edema in the frontal region adjacent to the sinus. Craniotomy was performed to access and drain the abscess. The sinus mucosa was removed and obliterated. Following several courses of intravenous antibiotic treatment, fortunately, no neurological sequelae were observed in the discharged patients.

In sum, our study highlights the critical importance of interdisciplinary collaboration in managing complex frontal sinus-related pathologies with dural invasion or involvement. While our findings offer valuable insights into the prevalence and implications of these cases, there remain several avenues for future research in this field.

Firstly, prospective studies with larger sample sizes and longer follow-up periods are needed to provide more robust evidence of the benefits of collaborative surgical approaches. Tracking patient outcomes over an extended period will allow for a more comprehensive assessment of the durability of surgical interventions and the potential for long-term complications.

Secondly, exploring the role of advanced surgical techniques and technologies, such as intraoperative navigation and minimally invasive approaches, in managing these challenging cases could further enhance patient outcomes. Investigating the impact of these innovations on surgical success rates and postoperative recovery is an exciting avenue for future research.

Additionally, the development of standardized protocols and guidelines for the evaluation and management of frontal sinus pathologies involving intracranial extension can help ensure consistency and optimize patient care. Comparative studies evaluating different treatment approaches and their associated outcomes may inform the creation of such guidelines.

Furthermore, a deeper understanding of the anatomical variations and factors contributing to dural invasion in specific pathologies can aid in risk stratification and treatment planning. Investigating the genetic and molecular markers associated with these pathologies may also open new avenues for targeted therapies and personalized medicine.

Lastly, studies that focus on the patient's perspective and quality of life following surgery for frontal sinus pathologies could provide a more holistic view of the impact of these procedures.

In conclusion, our study serves as a stepping stone for future investigations into the complex world of frontal sinus pathologies. By addressing these suggested areas of research, we can collectively advance our understanding, improve patient outcomes, and further refine the collaborative approach advocated in this study.

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Ethical Approval: Ethical approval was obtained from the Clinical Research Ethics Committee of Antalya Education and Research Hospital by its decision dated 24.08.2023 and numbered 11/25.

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Conflict of Interest: Authors declared no conflict of interest.

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