

Management of frontal sinus fractures requiring surgical intervention: An analysis of a case series

Authors' Contribution:

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ABSTRACT:

Introduction: Isolated fractures of the frontal bone constitute 5–15% of traumatic facial fractures, with frontal sinus fractures being divided into those of the anterior wall, the posterior wall, and complex fractures. The approach is selected according to the type of fracture and the displacement of the bone fragment. This paper summarizes the surgical management of patients with isolated and complex fractures of the anterior wall of the frontal sinus.

Material and methods: Five patients with different fractures of the frontal sinus were treated surgically. The same management protocol – diagnosis and surgical intervention – was implemented in all cases. Retrospective analysis included assessment of the fracture and the surgical approach, as well as evaluation of long-term outcomes.

Results: The most common cause of the fractures was falls, and two complex fractures involved the anterior and posterior walls. External approach, bone fragment removal, endoscopy, and external stabilization were used in all cases. One patient required delayed revision surgery due to a retained metallic foreign body. Follow-up radiological examinations showed that normal healing and cosmetic outcomes were satisfactory in all of the cases.

Conclusion: Surgical management of isolated fractures of the frontal sinus anterior wall, involving removal of bone fragments, realignment, and endoscopy, yielded satisfactory functional and cosmetic outcomes without internal or external stabilization. Long-term monitoring and symptom assessment are crucial, especially in cases with penetrating injuries and foreign body risk.

KEYWORDS:

anterior wall of the frontal sinus, forehead asymmetry, frontal bone fractures, frontal bone necrosis, frontal sinus injury, isolated frontal bone fractures, nasal endoscopy

INTRODUCTION

Isolated fractures of the frontal bone occur in approximately 5–15% of cases of traumatic facial fractures. Fractures involving the frontal sinuses can be classified into three types: fractures of the anterior wall, the posterior wall, or both, referred to as complex fractures, with isolated fractures of the anterior wall accounting for the majority of cases (33–39%) [1, 2]. Despite years of research and analysis on the management of frontal sinus fractures, there are no uniform guidelines in this area. The diagnostic and therapeutic approach depends on the type of fracture and the presence of bone fragment displacement [3]. If a fracture is detected with no displacement or with a displacement of less than 5 mm, the patient is usually observed, given prophylactic antibiotics, and advised to undergo follow-up imaging to assess for complications. However, if there are complications or frontal sinus deformities due to the injury, surgical intervention is required [4].

This article summarizes the surgical management of patients with isolated and complex fractures of the anterior wall of the frontal sinus.

MATERIAL

Between September 2021 and December 2022, 5 patients (4 men and 1 woman) aged 22, 29, 41, 51, and 75 years, with frontal sinus fractures underwent surgical treatment at the Department of Otolaryngology and Laryngological Oncology, CM UMK in Bydgoszcz. The follow-up period ranged from 6 to 13 months.

METHODS

The analysis was conducted retrospectively and involved the assessment of the extent and type of frontal sinus fractures, the surgical approach used, and the evaluation of long-term outcomes, including symptoms and radiological changes. The long-term outcome assessment also included cosmetic aspects related to the surgical procedure, such as forehead symmetry and sensory disturbances.

The study design was approved by the Bioethical Committee of CM UMK in Bydgoszcz (No. KB 52/2022).

Tab. I. Summary of treatment outcomes for patients with frontal sinus fractures.

NO.	AGE	GENDER	CAUSE OF FRACTURE	SIDE	THE EXTENT OF THE FRACTURE	CT SCANS	SKIN OVER THE FOR-HEAD	SURGERY DAY AFTER TRAUMA	SPECIAL SURGICAL CONSIDERATIONS	REVISION SURGERY	FOLLOW-UP (MONTHS)	COMPLAINTS	COSMETIC OUTCOMES: FORHEAD SYMMETRY SCORE: 1 – LACK OF SYMMETRY 5 – FULL SYMMETRY	COSMETIC OUTCOMES SCORE
1	41	Male	motor-cycle accident	Right	isolated anterior wall	Fracture of the anterior wall of the right frontal sinus deflections and displacements of fracture fragments relative to each other	open wound	7			8		5	visible
2	22	Male	fall from a height	Right	isolated anterior wall	Fracture of the right anterior wall of the frontal sinus deflections and displacements of fracture fragments relative to each other	intact	3	tissue glue		10		5	non visible
3	75	Male	shrapnel impact	Right	isolated anterior wall	Fracture of the right anterior wall of the frontal sinus Small and larger fragments of metallic foreign bodies up to 9 mm in the lumen of the right frontal sinus and in the right preseptal orbit	open wound	8		11 months	13		4	visible
4	51	Female	fall from a height	Left	complex fracture	Fracture of the left anterior wall of the frontal sinus fracture of the ethmoid with deflections and displacements of fracture fragments Fracture of the nasal bones	open wound	2			9	headaches, numbness of the skin over the forehead, presuer and discomfort in the supraorbital region.	4	visible
5	29	Male	fall from a height	Right	complex fracture	Fracture of the frontal bone on the right side; fracture fissures pass through the anterior and posterior walls of the sinus bone fragments of the anterior wall invaginated to a varying degree into the lumen of the sinus fracture line also passes through the roof of the right orbit, the ethmoid bone	open wound	2			6		4	visible

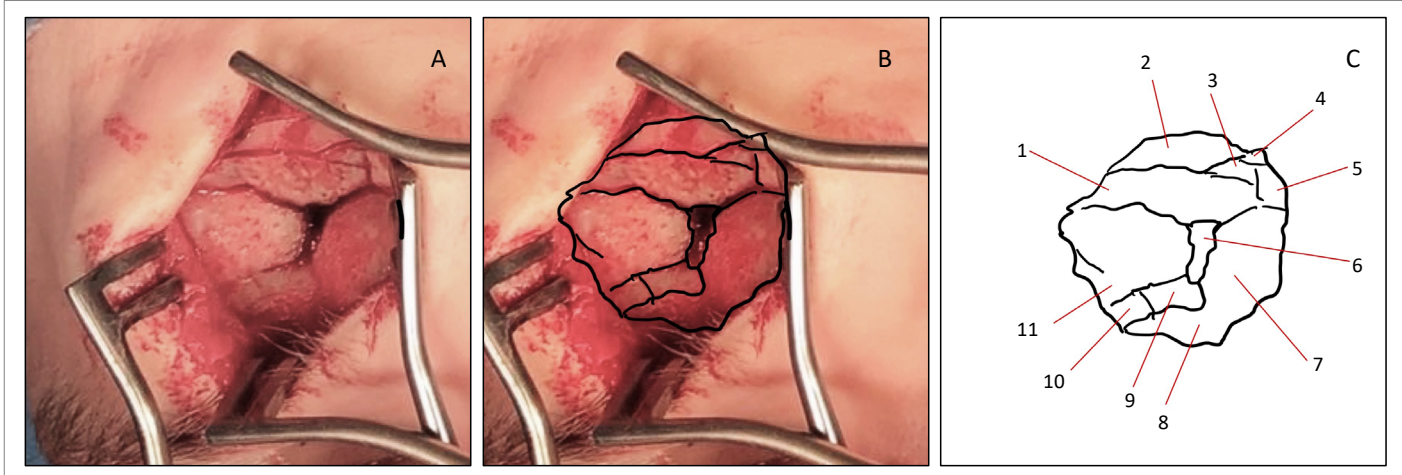


Fig. 1. Fracture of the anterior wall of the frontal sinus with depression: (A) – visible outline of the fracture, (B) – fracture contour, and (C) – number of bone fragments.

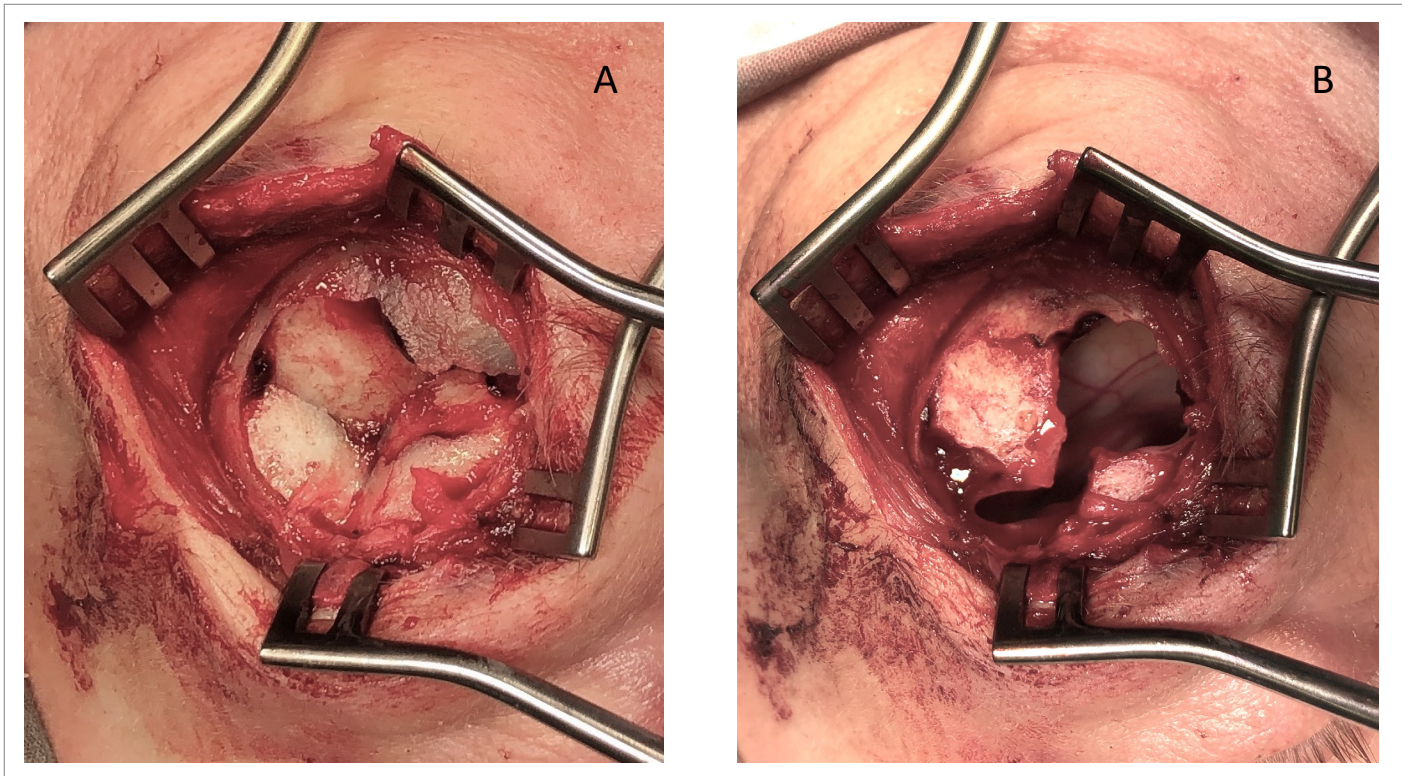


Fig. 2. Visible damage to the anterior wall of the frontal sinus before (A) and after (B) removal of bone fragments and stabilization.

RESULTS

The most common cause of frontal sinus fractures was trauma related to a fall ($n = 3$), while the remaining traumas were caused by a motor vehicle accidents and by a piece of an angular grinding disk. Among the patients, 3 had fractures involving only the anterior wall, whereas 2 had complex fractures encompassing the anterior wall of the sinus with displacement, fractures of the posterior wall, and fractures extending to adjacent structures. No cerebrospinal fluid leak was observed in any patient (Tab. I.).

The surgical treatment was the same for all patients. It involved an external approach, removal of bone fragments, endoscopic evaluation of the sinus cavity, and external stabilization. In two cases, the surgical

procedure was performed on the second day after injury, and in one case each on the 3rd, 7th, and 8th day following the injury.

In each case, access to the sinus cavity was obtained through the primary opening resulting from the injury ($n = 3$), through an incision at the site of the previous scar ($n = 1$), or at the eyebrow arch ($n = 1$). In the patient with depression of the anterior wall of the sinus without damage to the skin, an incision was made along the eyebrow arch on the side of the fracture. After the skin at the fracture site was dissected, smaller bone fragments that were not connected to the bone edges and fragments without periosteum were removed. Endoscopy of the frontal sinus was performed (using a 4-mm, 0- and 30-degree endoscope) in each case to assess the cavity, clean it, and identify any additional injuries.

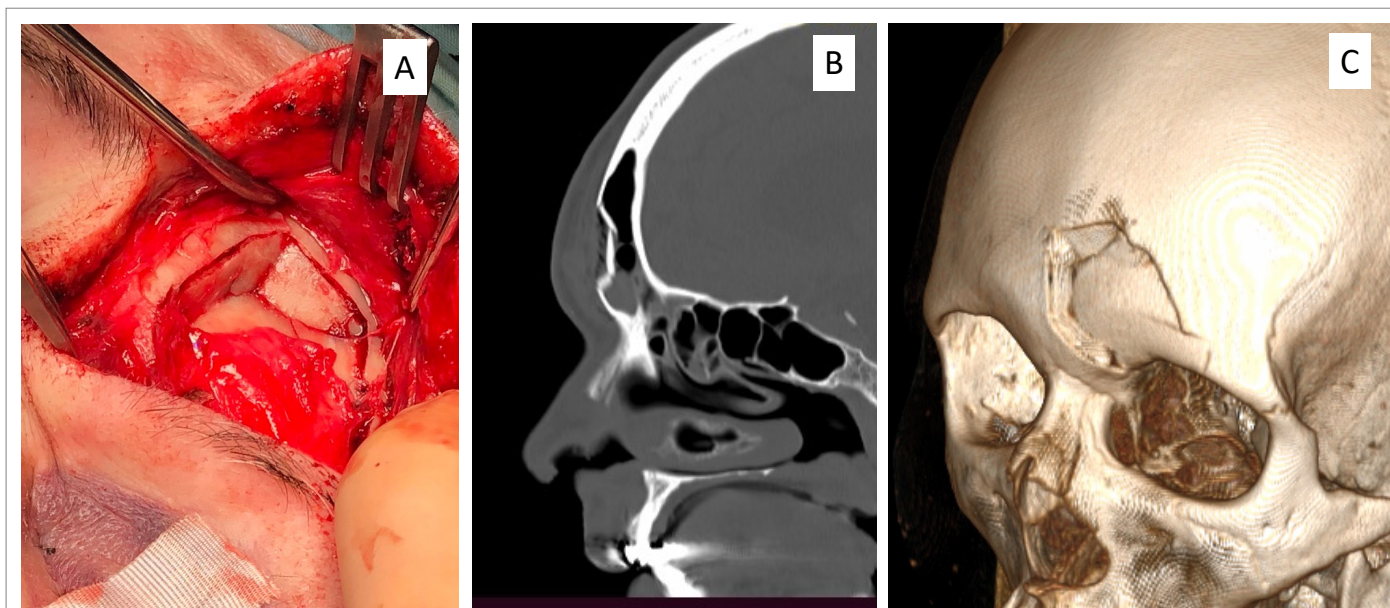


Fig. 3. Fracture of the anterior wall of the frontal sinus with intact skin: (A) – exposed frontal bone, (B) – CT scan, Sagittal plan, and (C) – CT 3D reconstruction of the fracture.

Subsequently, larger bone fragments were passively stabilized using the periosteum and the structure and shape of the bony framework; no plates or other stabilizing elements were used for stabilization and reconstruction. In one case, tissue adhesive was used to hold the bone fragments together. Postoperative dressing included immobilization of the forehead area with a plaster dressing for 7 days.

Follow-up radiological examinations performed 3–7 months after the surgical treatment showed proper healing of the bone, without signs of infection or necrotic tissue. In one case, a metallic foreign body was detected in the lateral recess of the frontal sinus. The patient was scheduled for a repeat surgery, during which the metallic foreign body was located and removed from the lateral recess of the frontal sinus. Subsequent follow-up revealed no complaints from the patient.

In the patients' subjective assessment, one individual reported discomfort and numbness in the operated area. Satisfactory cosmetic outcomes were achieved in all patients, primarily in terms of eliminating visible forehead deformities resulting from the injury.

DISCUSSION

The choice of surgical method always remains relative, largely dependent on patient-related variables (type and extent of the injury, presence of concomitant damage to adjacent anatomical structures, occurrence of complications of the injury, and coexisting medical conditions) as well as external factors (experience of the institution, availability of equipment, etc.). An essential aspect of selecting the surgical method is also achieving a satisfactory cosmetic outcome after the therapy, without forehead deformities or visible scars [1, 5]. In the study group, the choice of the surgical approach appears to have been correct. The time interval from injury to surgical intervention varied (from 2 to 8 days), but did not influence the final treatment outcome, with a minimum follow-up period of

6 months. Except for one case, single-stage surgical treatment with subsequent outpatient care did not require additional interventions. Follow-up CT examinations of the sinuses revealed normal healing and stabilization (calcification) of the remaining bone fragments, and the cosmetic effect was deemed very good, without additional scars or forehead deformities.

Nevertheless, based on our analysis, it should be emphasized that in cases of penetrating injuries with a suspected foreign body, the choice of the surgical approach should be very cautious and should consider the risk of leaving a foreign body behind. In the study group, one patient required reoperation due to the retention of a foreign body, which led to symptoms 11 months after the initial trauma and first surgical intervention. Although the treatment protocol included endoscopic evaluation, sinus cleaning, and inspection, a small fragment was not removed. Therefore, consideration should be given to performing intraoperative or immediate postoperative radiological examinations in patients with contaminated wounds or who reported non-specific symptoms [6].

The choice of surgical management was related to the extent of the injury. A differentiating factor in frontal sinus fractures that affects the choice of treatment is the involvement of the posterior sinus wall and the presence of cerebrospinal fluid leakage [7]. In the case series presented here, 3 patients had isolated fractures of the anterior wall, while 2 patients had complex fractures involving the posterior wall of the frontal sinus as well. No cerebrospinal fluid leakage was observed in any patient, and the fractures of the posterior wall of the frontal sinus were non-displaced cracks, hence the surgical intervention aimed at wound management, depression reduction, and elimination of infection risk.

The determining factor in the decision to remove or retain a bone fragment was whether it was connected to the inner or outer periosteum. Loose fragments and tissue at risk of necrosis (necrotic tissue) were removed, even if the fragment could have potentially

been the basis for reconstructing the anterior wall of the sinus. The primary goal was to limit the risk of infection, the development of necrosis, and any subsequent forehead deformity which could risk inflammation in the frontal sinus or lead to fibrous scarring lesions within the sinus or its opening [8, 9]. The decision to avoid external stabilization was made by considering the thickness and size of the bone fragments potentially requiring such stabilization, as well as the size and thickness of the stabilization sets that could affect the forehead shape and interfere with the quality of future radiological images [10].

In the discussion on the management of fractures of the anterior wall of the frontal sinus, endoscopic procedures should be highlighted as an alternative to external approaches and conservative treatment [11]. Endoscopic approaches are often preferable due to their lower complication rates, faster recovery, and satisfactory esthetic outcomes [12, 13]. However, the limited field of view (compared to external approaches) and potential difficulties in mobilizing or removing impacted bone fragments (requiring greater force than endoscopic instruments can provide) should be taken into account. Additionally, there remains the issue of skin damaged during the injury that needs to be treated separately (leaving a scar), regardless

of the endoscopic procedure. Conservative management is also an option in possible scenarios for the treatment of isolated frontal sinus fractures [14]. In cases of non-displaced fractures (depression), this is the treatment of choice, but any alteration in the bone contour at the fracture site should be individually analyzed.

CONCLUSIONS

The management of isolated fractures of the anterior wall of the frontal sinus – involving the removal of free bone fragments, realignment of the remaining bone segments through an external approach, and endoscopic revision – proved to be sufficient for proper healing without the need for internal or external stabilization. The final functional and cosmetic outcomes were satisfactory, with preserved forehead symmetry and an absence of post-traumatic scars. Nevertheless, detailed monitoring of long-term treatment outcomes and thorough assessment of patients' symptoms should be an integral part of the therapeutic approach, especially in patients with penetrating injuries and a high risk of foreign body retention.

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