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| RESEARCH ARTICLE

Surgical Treatment of Closed Fracture of the Anterior Wall of the Frontal Sinus with Displacement by the ORIF Technique using a Titanium Plate: A Case Report

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| ABSTRACT

Fractures associated with anterior and posterior frontal sinus walls are among the most challenging cranio-maxillofacial injuries. These represent a major emergency, having a potentially severe clinical picture, with intracranial hemorrhage, cerebrospinal fluid leak, meningeal lesions, pneumocephalus, contusion or laceration of the brain matter, coma, and in some cases, death. In this article, we present the case of a 32-year-old patient with the diagnosis of: Closed fracture of the anterior wall of the frontal sinus with displacement, fracture of the posterior wall of the frontal sinus without displacement and impairment of the upperface bone architecture. Despite the severity and complexity of the case, early initiation of correct ENT surgery, using ORIF (open fracture alignment and internal fixation) technique, led to the successful reconstruction and redimensioning of upperface architecture and to the restoration of the patient's physiognomy. This article describes a case report on the use of titanium plates for the reconstruction of the upper aesthetic area of the face. The article also describes the use of the ORIF technique, its description, and its advantages, as well as a literature review in order to show its advantages in the avoidance of postoperative complications. The purpose of the work is to describe a new technique that helps to avoid aesthetic and functional complications in the future, which will be useful to otorhinolaryngologists and maxillofacial surgeons.

| KEYWORDS

Frontal bone fracture, maxillofacial, trauma, open reduction, titanium plate, frontal sinus.

| ARTICLE INFORMATION

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1. Introduction

Fractures of the frontal sinus are relatively rare and account for 5–12% of all fractures of the facial skeleton (Kim, 2016). This is due to the fact that the front wall of the frontal sinus is formed by a thicker layer of cortical bone (2-12 mm) and has a sufficiently curved spherical shape, so it is much more resistant to fractures than any other facial bone (Bourry, 2019). This type of injury is more common in men in their fourth decade of life and most often occurs as a result of a traffic accident in which the patient hits his face on the dashboard or steering wheel. The use of shoulder seat belts and airbags in cars has reduced the frequency of frontal sinus fractures (Lee, 2022). Unlike the front wall, the back wall of the frontal sinus has a much smaller thickness (0.1 - 2.2 mm).

Today, numerous schemes of classification of frontal sinus fractures have been proposed. Of all the studies, the classification based on the involvement of the frontonasal duct best helps determine the treatment algorithm for frontal sinus fracture from conservative treatment to surgery (Egemen, 2013). However, it should be remembered that an injury of the frontonasal duct is not always easy to detect on computed tomography (CT)(Arnold, 2019). The main factors that determine the treatment algorithm are the patency of the frontonasal duct and the presence of cerebrospinal fluid leak (CSFL), trauma to the dura mater, traumatic brain tissue damage, the presence of neurological deficits, etc. (Fig. 1.).

2. Literature review and discussion

The classification of frontal sinus fractures by Manolidis S., William M. Weathers, 2013 (Fig. 1) is the most complete today (Fig. 2).

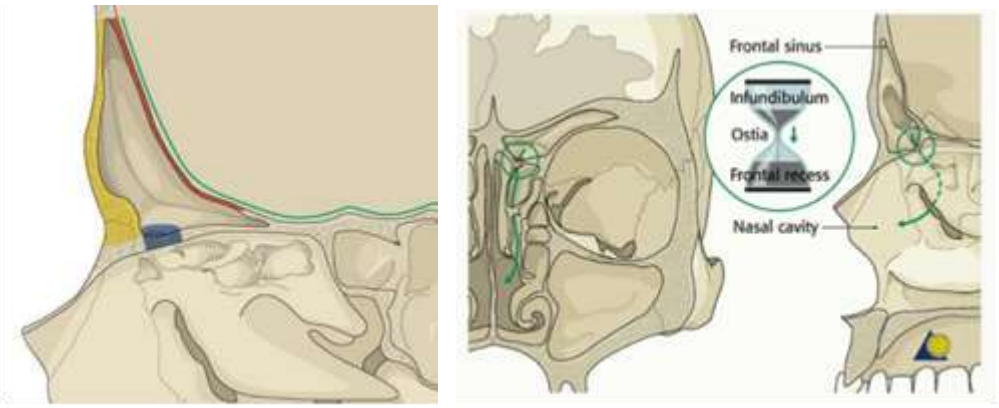

Fig. 1. Anatomical parameters that must be evaluated when planning treatment tactics for traumatic damage to the frontal sinuses. Yellow color – the front wall of the frontal sinus; red – the back wall of the frontal sinus; blue – the frontonasal duct; green – involvement in the process of the dura mater (Weathers, 2013).

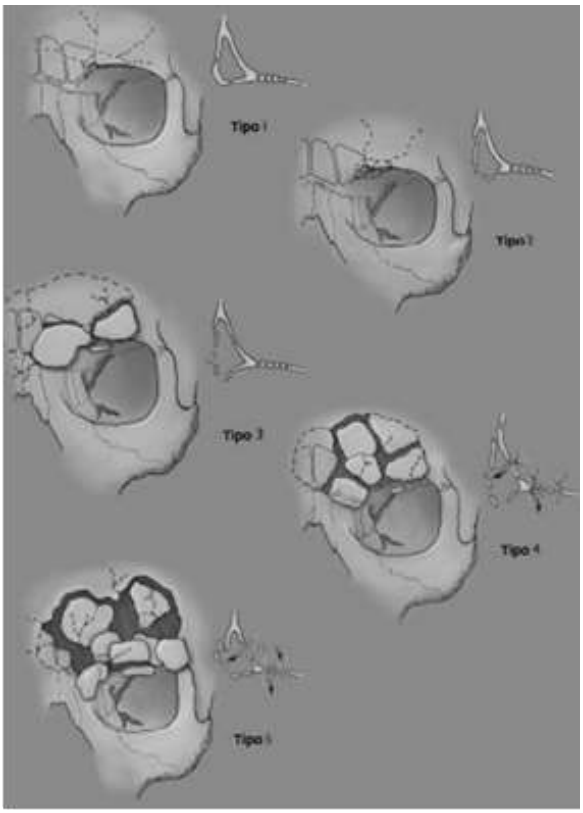

Fig. 2. The classification of frontal sinus fractures. Type 1 - linear fractures of the front wall of the frontal sinus with slight displacement; type 2 - crushed or depressed fractures of the front wall with involvement (obturation) of the frontal-nasal duct; type 3 - small fractures of the front and back walls of the frontal sinus; type 4 - these are comminuted fractures of the front and back walls with traumatic damage to the dura mater and liquefaction; type 5 - comminuted fractures of both the anterior and posterior walls of the frontal sinus with damage to the dura mater and cerebrospinal fluid leak, significant bone defects, and soft tissue and bone tissue damage (Weathers, 2013).

During the objective examination, in addition to assessing the general condition and ENT status, it is necessary to assess the neurological status. It is necessary to pay attention to rhinorrhea (unilateral or bilateral, immediately occurring or in a remote

period), complaints of visual disturbances that occurred after the injury, headache, primary and/or repeated loss or disturbance of consciousness, assess the state of consciousness according to the Glascow Coma Scale (modified 1985).

Instrumental diagnosis is carried out with the help of computer tomography, which is performed in thin sections (1.0-1.2 mm; 0.1-0.2 mSv) in three planes - the gold standard for diagnosing traumatic lesions of the frontal sinus. Frontal images show the condition of the front and back walls and allow us to assess the degree of displacement of the debris. Moreover, special attention should be paid to the assessment of the presence of pneumocephalus, which indicates a more severe degree of injury and may require immediate surgical treatment in the department of neurosurgery. Coronal slices are used to evaluate the lower wall of the frontal sinus and the upper-medial edge of the orbit. Examination in the sagittal plane is useful for assessing the patency of the frontonasal duct. Performing a 3D reconstruction can help visualize deformities that are less visible when viewing a 2D image.

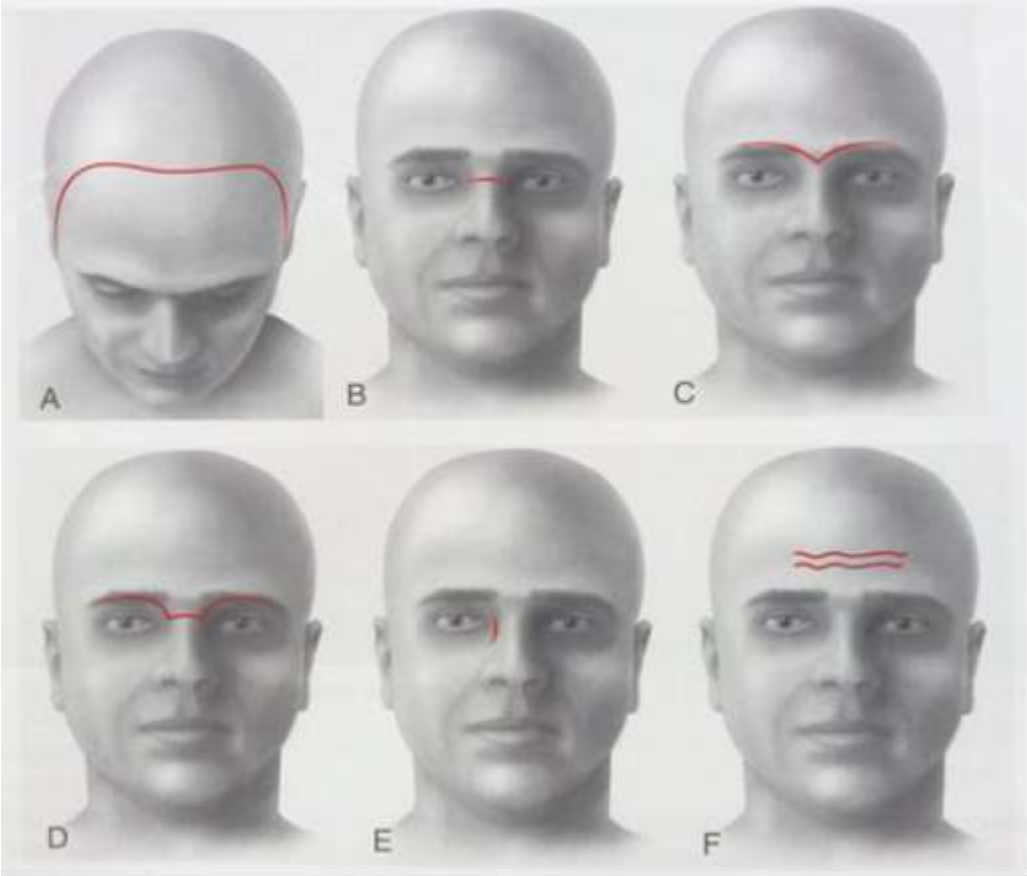

Fig. 3. Surgical approaches to the frontal sinus in case of its traumatic damage: A. Arc-shaped bilateral incision along Dondi (coronary), a line that passes through the coronary region from the temporal region to the contralateral side. B. Open-sky incisions, curved incisions in the medial orbital area, are bilaterally connected by a straight incision on the nasal bridge (0.5-1 cm below the glabella). C. Gull Wing, curved incisions in the eyebrow area or slightly below, bilateral, connected in the nasion area. D. Butterfly, a combination of Gull Wing and Open-sky cuts. E. Unilateral medial orbital incision. F. Approach through existing lacerations(Kühnel, 2015).

The main goal of treating frontal sinus fractures is to support sinus function, prevent complications, and restore facial aesthetics (Fig. 4.).

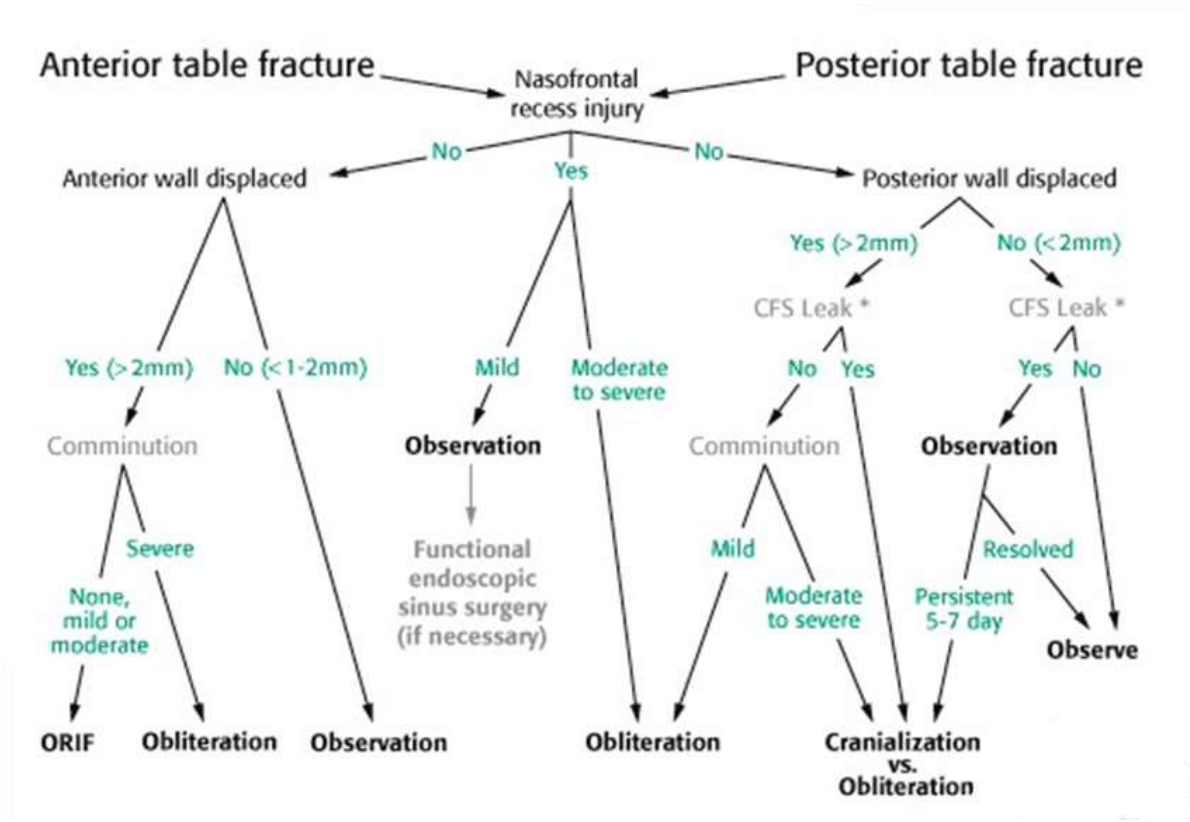

Fig. 4. Treatment algorithm for frontal sinus fractures. The algorithm is based on five anatomical parameters: fracture of the anterior wall, fracture of the posterior wall, damage to the integrity and functioning of the frontonasal duct, damage to the dura mater and the degree of comminution of bone fragments (Fattahi, 2016).

Fracture of the front wall of the frontal sinus. Undisplaced fractures of the anterior wall of the frontal sinus do not require surgical intervention. Displaced debris must be returned to its original location for two main reasons. The most important thing is that if there is any trapped mucosa between the edges of the fragments, there is a possibility for the development of a mucocele in this area in the future. The second reason is to prevent the inevitable deformity and aesthetic complications that will occur if the displaced fragment is not correctly positioned. If the fracture is open, it can sometimes be reduced through overlapping lacerations. If the skin break is too small to effectively reduce the fracture, then additional room for manipulation can be obtained by extending the skin breaks horizontally along the natural forehead skin fold line. The two most commonly used approaches are the "Gull Wing" (Fig. 3-C) or "Butterfly" (Fig. 4-D) incisions. Fracture fragments are lifted and grasped with a strong bone hook and clamp, and it is important to preserve the periosteum as much as possible - because it performs the function of a feeding vascular pedicle. The mucosa adjacent to the fragments is incised and removed, and the thin layer of adjacent bone is smoothed with a diamond bur. Fracture fragments are fixed in place with titanium mesh or titanium bone miniplates (splints).

Fractures associated with dysfunction of the frontonasal duct. An unrecognized injury to the frontonasal duct can lead to insufficient drainage of the frontal sinus with subsequent mucocele formation, infectious complications, neurological and neurosurgical complications, and persistent headaches. Intraoperative assessment of patency may be unreliable due to traumatic edema of the mucosa, although some authors advocate gentle probing of the frontonasal duct or, if possible, the introduction of a fluorescent dye to check the functioning of this junction.

Regardless of the damage to the anterior or posterior wall, injuries of the frontonasal duct leading to occlusion of the frontal sinus conjunctiva usually require obliteration of the frontal sinus. It is possible to carry out frontotomy both endoscopically and by open surgery. If the damage is unilateral, some authors advocate the removal of the septum between the sinuses, thereby allowing drainage through the contralateral fronto-nasal tract [9]. This strategy is not widely supported because it opposes the laws of mucociliary clearance. Another option is long-term cannulation of the fronto-nasal outflow tract, as described by Luce, but this contributes to the formation of circumferential scars with stenosis of the outflow tract. Currently, the endoscopic version of Draf III (modified by Lothrop), also known as the "frontal sinus drill-out" operation, is very popular. Classic open methods are the Lynch operation with the Sewell-Boyden flap. For the Sewell-Boyden flap, part of the mucoperiosteum flap is taken from the nasal septum or from the lateral wall of the nose in front of the turbinates. Then, the flap is used so that it is laid out and enlarged by the outlet

tract of the frontonasal duct. The most reliable method is the technique of using an osteoplastic flap with fat obliteration or cranialization.

The treatment of posterior wall fractures is the most controversial. With displaced fractures of the posterior wall, the risk of damage to the dura mater is significant. The main question is whether it is necessary to carry out surgical intervention if the displacement of the fragments is insignificant (without the involvement of the frontonasal duct, without CSFL or involvement of the dura mater) - the tactics of waiting and observation are recommended.

If the fragments of the back wall of the frontal sinus are severely crushed, according to the data of the world literature, cranialization will be the best option. A pericranial flap can be used to separate and delineate the nasal and frontal cavities in patients with ethmoid plate injuries and thus increase the space for reconstructive surgery of the skull base and the possibility of manipulation of the dura mater.

When only the back wall of the frontal sinus is affected by the need to close a small defect and without nasal fluid, foreign literature describes methods of endoscopic access using a modified Lynch-Howarth incision (Fig. 5).

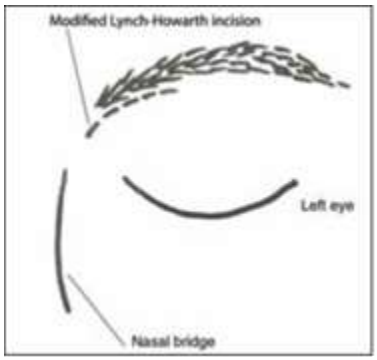

Fig. 5 Modified Lynch-Howarth incision for a fracture exclusively of the back wall of the frontal sinus (Murr, 2010).

Patients who suffered a frontal sinus injury and received timely and necessary treatment have a good prognosis. Complications are 1%-3% with obliteration of the frontal sinus and reach 10% with non-obliterative treatment. Excellent results of endoscopic treatment using the Draf III technique (modified by Lothrop) are reported - frontal sinus drill-out surgery is the method of choice if the necessary endoscopic skills and equipment are available. Currently, obliteration in cases of damage to the fronto-nasal tract and damage to the posterior wall of the frontal sinus with displacement remains the gold standard.

Open reduction and internal fixation (ORIF) is a type of treatment for a fragmented fracture of the anterior wall of the frontal sinus. It helps put pieces of broken bone back together so they can heal. Open reduction (reduction) means that the bones (autologous skull bone graft) are moved back into place during surgery. Internal fixation means the use of special equipment, namely the use of titanium mesh made in situ to hold the bone fragments on its surface. Other options for reconstruction include the use of titanium mesh printed individually for the patient from a 3D model. In the articles of recent years, it has been reported that the use of porous plastic (for example, Porex®) for the reconstruction of similar cases has yielded a satisfactory result (Hosseini, 2016).

Titanium mesh is widely used in reconstructive surgery of the frontal area, surgery of the lower and upper jaw, and zygomatic and orbital areas. There are several advantages to using titanium mesh for maxillofacial reconstruction and cranial vault defects; namely, titanium has excellent biocompatibility and minimal inflammatory response (Sakat, 2016). In addition, titanium is safe and creates minimal image artifact in CT scans. Small bone fragments can be individually attached to the mesh by simply drilling a hole and screwing the bone to the mesh, reducing the need for a bone graft, which was done in our case described below. Long-term results of repair of anterior wall defects of the frontal bone with titanium mesh reported significantly good results and virtually no intra- and postoperative complications.

There are other complications of improper treatment of a frontal sinus fracture: aesthetic complications, infectious, chronic/acute purulent frontitis due to lack of drainage of the fronto-nasal junction, mucocele/mucopiocele, osteomyelitis of the frontal bone, meningitis, encephalitis, encephalocele, Pott's tumor (Pott's puffy tumor).

3. Case Report

Patient T., 32 years old, entered the Institute of Otolaryngology, named after Prof. O.S. Kolomiichenko of the National Academy of Medical Sciences of Ukraine, with complaints of difficulty in nasal breathing, rhinorrhea, deformation of the upper third of the face, pain in the projection area of the frontal sinuses.

These complaints arose as a result of an injury received 1 month ago due to the impact of a metal rail on the forehead. He did not consult a doctor. According to the patient, he did not lose consciousness. There were no manifestations of general brain symptoms. Consulted in the regional hospital of his region. CT of the head - a fracture of the bones of the facial skull was established (part of the frontal sinuses, hematosinus). Referred to the State University "Institute of Otolaryngology named after Prof. O.S. Kolomiychenko National Academy of Sciences of Ukraine". On examination during anterior rhinoscopy, the mucous membrane is pale pink, not swollen. Nasal septum S-shaped curved to the left. Nasal breathing is difficult. During the examination, a closed depressed fracture of the front walls of both frontal sinuses is determined. The area of the fracture is about 4*3 cm. Other ENT-organs at the time of examination without pathological changes. Taking into account the MSCT data of the head, the patient was diagnosed with a closed fracture of the anterior wall of the frontal sinus with displacement fracture of the posterior wall of the frontal sinus without displacement. Frontite Curvature of the nasal septum. The patient underwent a surgical operation: septoplasty, plastic surgery of the front wall of both frontal sinuses, MOS. A "Gull Wings" (Fig. 8.) hook-shaped incision was made under the ETN in section m. procerus, the periosteum was peeled off, and fragments of bones - the front wall of both frontal sinuses - were visualized. From their inner (convexital) side - submucosa exfoliated fragments - fragments are removed. Revision of both frontal sinuses was performed. In the left frontal sinus, there is a significant amount of purulent content. The back wall of the left frontal sinus contains scarred tissue - the site of scarring was not removed for the sake of tightness of the back wall of the frontal sinus, and the displacement of the back wall of the frontal sinus is up to 2 mm (Fig. 6.). Revision of the frontal sinuses was performed, the confluence of the right frontal sinus was visualized, the intersinus septum was removed so that the sinus was drained through the contralateral confluence. A plastic bone defect of the front wall of the frontal sinus was performed using a titanium plate (Fig. 7.). The size of the plate is 1.0 cm on each side, larger than the size of the bone defect. Bone fragments were screwed to the plate. The sharp edges were previously smoothed with a bur and connected to the whole bone edge. Seams are applied in layers, and an aseptic bandage is applied.

During inpatient treatment, he received cephalosporins of the 3rd generation, tranexanic acid preparation, painkillers, and GCS intravenously.

He was discharged from the hospital on the 11th day in a satisfactory condition.

Fig. 6. The displacement of the fragments of the back wall of the frontal sinus is up to 2 mm. The back wall of the left frontal sinus contains scar tissue, which was not removed for the sake of tightness of the back wall. Revision of the frontal sinuses was performed, and the intersinus septum was removed for drainage through the contralateral conostomy. Source: compiled by the authors.

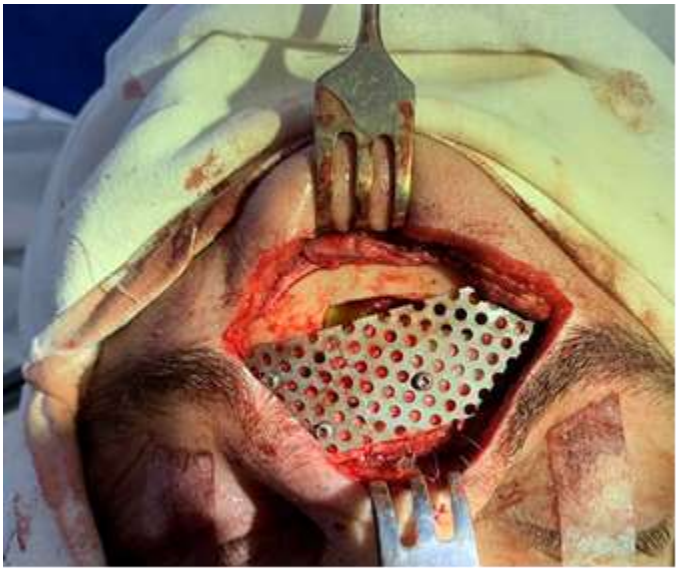

Fig. 7. A plastic bone defect of the front wall of the frontal sinus was performed using a titanium plate. Bone fragments are screwed to the plate; the sharp edges were previously smoothed with a bur and connected to the whole bone edge. Source: compiled by the authors.

Fig. 8. Hook-shaped incision "Gull Wings" in section m. procerus, at the final stage of the operation, a satisfactory aesthetic result was obtained - the correct contour shape of the forehead. Source: compiled by the authors.

4. Conclusion

When planning treatment tactics in patients with traumatic lesions of the frontal sinuses, such parameters as lesions of the frontonasal duct, fragmentation and displacement of the anterior and posterior walls of the frontal sinuses, involvement of the dura mater in the process must be evaluated. Significantly comminuted fractures of only the anterior wall of the frontal sinus can be easily reconstructed with titanium mesh and the ORIF (open fracture alignment and internal fixation) technique, providing excellent forehead contouring. The titanium mesh is easy to process and provides good strength and stability. It is easily and quickly fixed to the bones, creates a surface for the stabilization of fragments, does not palpate through the skin, and provides a reduction in the time of surgical intervention. Reconstructive surgery with the help of titanium mesh gives significantly good aesthetic results and practically no intra- and postoperative complications and can be the method of choice for traumatic lesions of the anterior wall of the frontal sinus with significant displacement of fragments.

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List of abbreviations:

CT - Computed tomography

CSFL -Cerebrospinal fluid leak

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