



Appropriate Pathways and Surgical Approaches in the Fractures of the Frontal Sinus

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Abstract: Fractures of the frontal sinus are part of the fractures of the border between the facial and the cranial regions. They cause both aesthetic and vital problems, but also functional, requiring rapid and global care in a multidisciplinary setting. The document provides a descriptive and cross sectional study with prospective data collection, conducted in the department of Maxillofacial and Aesthetic Surgery of the Mohammed 6 Teaching Hospital of Marrakech, describe describe 18case operated for frontal sinus fractures over a 2-year period. The ideal time of repair was beyond the 72nd hour, at best between the 8th and 15th days after the reduction of cerebral and facial edema and the exclusion of any lesions that require emergency intervention. Our indications were mainly influenced by aesthetic deformities, impaction and embarrure fracture of ethmoidal and orbital roofs with clinical expression, obliteration of the naso-frontal duct, posterior wall displacement predicting dura mater laceration, and by the time to management. The coronal approach was the most indicated with 83, 33% of the cases. We realized sinus exclusion in 72.22%, cranialization in 22.77%, and repair of dura mater injuries in 27.77%. The sequelae found in 27.77%, were essentially functional and aesthetic.

Keywords: Craniofacial Trauma, Frontal Sinus Surgery, Cranialization, Exclusion of Sinus

1. Introduction

Fractures of the frontal sinus represent post traumatic injuries, open or closed around one or both walls of the frontal sinus, causing the communication of the intra sinus content with the asbestos medium. They are often associated with other fractures, particularly at the level of the facial plate, complex nasomaxilloethmoidal, and orbital fracture [1-3].

They are exceptional in children, rare in adolescents, more frequent in adults [4]. They are potentially serious, with the main risk, the meningo-encephalic involvement causing the passage of cerebrospinal fluid (CSF) in the sinus cavity, and cause the occurrence of life-threatening complications [2]. In addition, these lesions often cause functional and aesthetic sequelae [5]. That said, these fractures should not be underestimated and should require good lesional exposure for a precise, rigorous and precocious surgical approach, which

is not always easy and, to this day, remains non-consensual [3]. It is with this in mind, that we lead this study whose purpose is to discuss the different pathways and, to state our indications and surgical approaches in fractures of the frontal sinus.

2. Patients and Method

2.1. Type and Period of Study

We present a descriptive and cross sectional study with prospective data collection, conducted in the department of Maxillofacial and Aesthetic Surgery of the Mohammed 6 Teaching Hospital of Marrakech, over a period of 2 years from June 2015 to June 2017 with a mean follow-up of 16 months.

Eighteen (18) patients who have benefited a surgery for frontal sinus injury were retained out of the 25 cases of

fractures executed in this period of study.

All patients hospitalized for frontal sinus fractures, isolated or not, were included. Any fracture that does not require a surgical indication was excluded.

All the patients were assessed for functional signs (headache, hyposmia, anosmia, visual acuity, CSF flow) and morphology (frontal collapse, exophthalmia and enophthalmia). Computed tomography was also performed for all patients.

Our sample was then composed of 18 patients divided into two groups according to the delay of management: patients from group1 (G1) were taken care of the first 15 days and those from group2 (G2), after 15 days.

2.2. Variables Studied

We study the following variables:

Age, sex, etiology of trauma, time of admission, delay of surgery, presence or absence of

Cerebrospinal fluid, disorders of smell, type of injury according to the Ioannides et al classification [6] (Table 1), indication of surgery, appropriate pathways, the surgical gait, the complications, and the sequelae.

Table 1. Classification of Ioannides et al.

Staging	Stated Desional	Descriptions
Type I	fractures of the anterior Wall	IA Without dislocation, no damage of the nasofrontal duct
		IB High fracture of dislocation, not of the nasofrontal duct
		IC fracture with bone loss, not of the nasofrontal duct
		ID Low fracture with involvement of the nasofrontal duct
		IE fracture of all anterior wall with involvement of the nasofrontal duct
Type II	Posterior Wall fractures	IIA No dislocation, no cerebrospinal fluid (CSF) leakage, dislocation and/or bone loss, no CSF leak
		IIB dislocation and CSF leak
		IID extensive and comminuted for the posterior wall with the CSF leak
Type III	Fractures of both the anterior and the posterior walls	IIIA Type I + IIA or IIB IIIB Type I + IIC or IID.
Type IV	Comminuted fractures of all complex nasofronto-ethmoido-orbital.	

3. Result

The majority of our patients were young men (83.33%) with an average age of 31 years. The etiologies encountered in our series were dominated by road accidents (72.22%), followed by projections in the face mainly related to the assaults in 16.66% and falls from a height in 11.11%.

The delay in hospitalization ranged from a few hours after the trauma to 21 days.

61.1% of our patients were operated before the 15 days (G1) against 38.9% after the 15th day (G2). The decrease in visual acuity without ocular motility disorder or mydriasis was found in 11.11% of cases. No cases of exophthalmia or

enophthalmia were detected. The smell disorders were found in 16.7% of cases.

The aesthetic deformities were found in all of our patients.

Several types of bone lesions have been identified and ordered according to the classification of Ioannides et al. [6] (Table 2).

Table 2. Distribution of lesions according to the classification of Ioannides et al.

Type of Injury	Percentage
Type I	27,77
Type II	5,55
Type III	16,7
Type IV	50

Inconsistent rhinorrhea was found in 22.22% of cases. The meningeal breach was objectified in 27.77% of cases. The location of the breach was largely dominated by the ethmoidal localization (80%) and in 20% behind the posterior wall of the sinus.

Preventive antibiotic therapy and pneumococcal vaccination were performed in all patients in the series who had open trauma and rhinorrhea.

A unilateral coronary approach was performed in 38.9%, bilateral in 44.4%, by the scar in 16.7%. No endoscopic, brow bone or medial frontal (in a frontal wrinkle) approach was performed. We performed joint interventions with a neurosurgeon in 27.77% of patients. The techniques we used are shown in Table 3 (Table 3).

Table 3. Distribution according to reconstruction techniques.

Acts	G1	G2
Sinus exclusion without filling	7 cases	6 cases
Cranialization	4 cases	1 case
Suture for Small meningeal lacerations	2 cases	1 case
Pericranial flap (larger defects)	1 case	1 case
Titanium grid (If the bony defect of the anterior wall was big enough)	1 case	1 case

Our post-operative outcomes were mostly favorable (Table 4).

Table 4. General characteristics of the operative process.

Features	G1	G2
Inflammatory complications	0 case	1 case
Neurological worsening after surgery	0 case	0 case
Improvement of ocular function after surgery	yes	yes
Aesthetic sequelae	0 case	2 cases
Postoperative functional sequelae		
Hyposmia	2 cases	0 case
Anosmia	0 case	1 case
Headaches	1 case	1 case

No cases of perioperative death were observed.

4. Discussion

Fractures of the frontal sinus causing aesthetic as well as vital but also functional disorders, must require a global and immediate management by reducing the number of interventions and the duration of care [5]. The surgical treatment of frontal sinus fractures answered for three major concerns [7]: -Restoration of facial aesthetics by restoring the

relief of the anterior wall, in order to prevent the patient from the psychological experience of the disfigurement.

-Isolation of the intracranial structures and cessation of CSF leakage.

-Prevention of early post traumatic infection or late infectious sequelae such as mucopyoceles, osteomyelitis, intracerebral infections, etc.

The average age of our patients was 31 years. As many authors, we also found a clear male predominance, road accidents as the first etiology (72.22%) followed by assaults (16.66%) [4, 9-11]. This is explained by the fact that unlike women whose lifestyles are less exposed to risk factors [5, 12], this population is indeed more exposed to risky behavior during sports and car activities, and remains more involved in acts of violence.

38.9% of our patients were operated beyond 15 days. The reason being the reduction of the exclusion of any lesions that require emergency intervention and because of the cost of the osteosynthesis equipment completely at the expense of the patients.

Our ideal period of care was between the 8th and 15th days, after the reduction of cerebral and facial edema, and before the stagnation of the foci. Other authors like Bachli H. et al. also advocate for it [7].

Several types of lesions were found and indexed according to the Ioannides et al. classification, which is a simple classification that seems to be the most suitable for the management of frontal sinus fractures [2, 6].

Like Sakovich (28%), we found rhinorrhea in about 1 in 5 patients (22.2%) [7, 9], versus 27.77% of the meningeal breach. This means that the absence of cerebrospinal fluid does not mean the dura mater integrity, hence the interest of exploring the anterior stage of the skull base systematically. And this is reinforced by a no less classic aphorism: "Dry fistula is not breach closed" [2].

An anti-pneumococcal vaccination was still in order. The use of prophylactic antibiotic therapy is highly controversial and has not been shown to be effective in the prevention of meningitis in case of open trauma [3, 7].

Three types of approaches were used, including:

The bi-coronal or Cairns-Unterberger pathway as described in the literature was used in 44.4% of cases [13-15]. It was performed by first drawing the incision line using a dermographic pen that extended from one pre-tragic area to 1cm in front and 2cm above the root of the helix, to the other passing 4 to 5 cm behind the anterior line of implantation of the scalp. A curvilinear layout, departing forward at the level of the vertex was adopted in order to respect possible frontal gulfs.

In children, the incision line was placed well behind the anterior implantation line of the scalp so as to allow migration of the scar with growth. We recommend a broken zigzag incision line to reduce the risk of alopecia and keloid scars.

For the hemi-coronal approach, which was used in 38.9% of cases, the curve of the incision line extends beyond the median line and stops, anteriorly, behind the line

implantation of the scalp.

The cutaneous reference pattern was crossed in scale so as to constitute markers for closure. Subperiosteal subgaleal infiltration was then performed using an adrenaline solution to reduce bleeding and to perform hydro-dissection. The incision involved the skin, the subcutaneous tissues and the galea, until the opening of the Merkel space followed by the periostotomy (Figure 1.).

This coronal scalp incision, used in 83.3% of our patients, remains the pathways of choice. Simple and fast, it offers the best access of the frontal sinus, supra-orbital rim, roof of the orbit, medial and lateral walls of the orbit, the root of the nose, the zygomatic arch, the body of the malar, as well as the frontomalar process. In invasive appearance, it represents a path of safety with minimal morbidity, with better exposure of the lesions, promotes the ease of the gestures and an aesthetically acceptable scar. It has some disadvantages such as the long duration of operative time, and the cicatricial alopecia which can be minimized by a broken incision [13, 15].



Figure 1. Illustrations of the incision line of the broken coronal approach, exposure of the lesions after peeling of the scalp flap and periostotomy, and good projection.



Figure 2. Illustrations of two patients with frontal sinus fractures of the anterior wall, respectively directly approached, through a glabellar wound, enlarged secondarily in the ciliary extension; and through a frontal wound.

The transcutaneous or wound path represented the second pathway in terms of frequency with 16.7% of use. When the wound or scar was insufficient, the way could be widened by taking into account the skin tension lines (Figure 2.). It allows quick, easy access and is non-invasive. It gives a good direct and limited exposure to the sinuses but has the disadvantage of giving a random scarring that can be minimized by the respect of lines of cutaneous tensions.

No transnasal route was used for aesthetic reasons.

The choice of these routes was always, depending on the habits of the operator, motivated mainly by the need to have a good day surgery and a good cicatricial ransom.

The approaches and indications were as follows:

4.1. For Fractures of the Anterior Wall

- Fractures of the anterior wall without local soft tissue injuries that form an exception and do not need any intervention were removed from our study.

- Complex fracture (displaced to plus 2mm or comminuted) or open (Type IB-IE): exploration and exclusion of the sinus, then reconstruction of the anterior wall in 27.77% of cases.

4.2. For Fractures of the Anterior and Posterior Walls

-Simple fracture, little or no displaced posterior wall (Type IIA-IIC): if no CSF flow, In cases of an extensively fractured posterior wall, the debris, all small loose fragments and the mucosal

lining of the sinus was thoroughly removed and the cavity as well as the nasofrontal duct was filled up with cancellous bone harvested from the bone cleat, reconstruction of the anterior wall, if flow of (CSF) repair of the neuromeningeal breach in 5.55% of cases.

-Complex fracture of the displaced or comminuted posterior wall (Type IID): exploration of the sinus, dura mater repair, cranialization, reconstruction of the anterior wall, 11.11% of cases.

4.3. For Multiple Fractures (Type IV)

Fracture reduction and fixation was sequential: zygomatic arch, fronto-zygomatic suture, roof of the orbit and the Complex naso-ethmoido-fronto-orbital, 50% of cases. (Figure 3.).

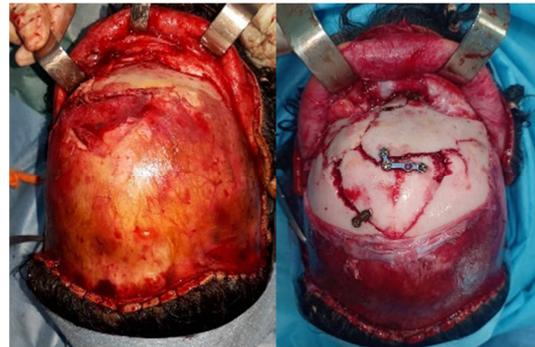
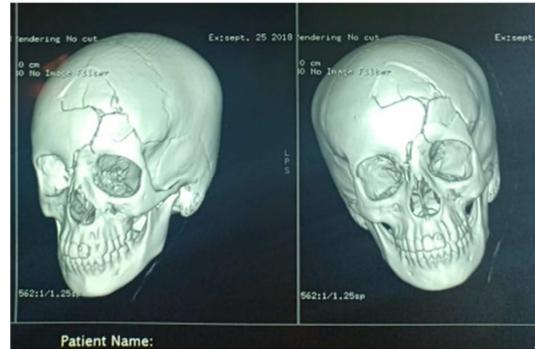
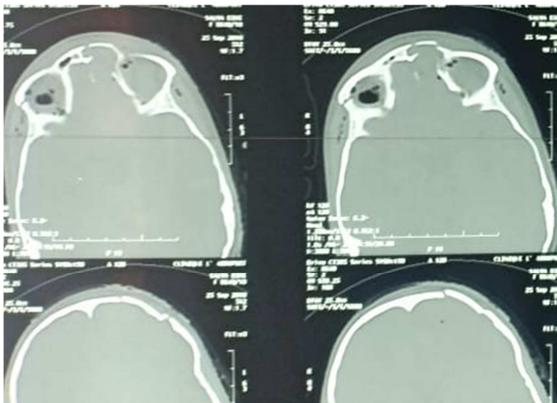


Figure 3. Illustration, type IV lesions of Ioannides et al., with frontal and posterior wall involvement and rhinorrhea treated by bi-coronal approach, reduction and cranialization, epicranial flap for hard grafting and mini-plate osteosynthesis.

4.4. For Losses of Substances from the Anterior Wall

In addition 1-2 cm × 2-3 cm, the repair was performed by titanium plates (dynamic mesh titanium) in 11.11% of cases in our sample (Figure 4.).

We do not advocate the use of bone graft as it has been reported by some authors, because it can partly resorb, thus leading to secondary deformities [6].



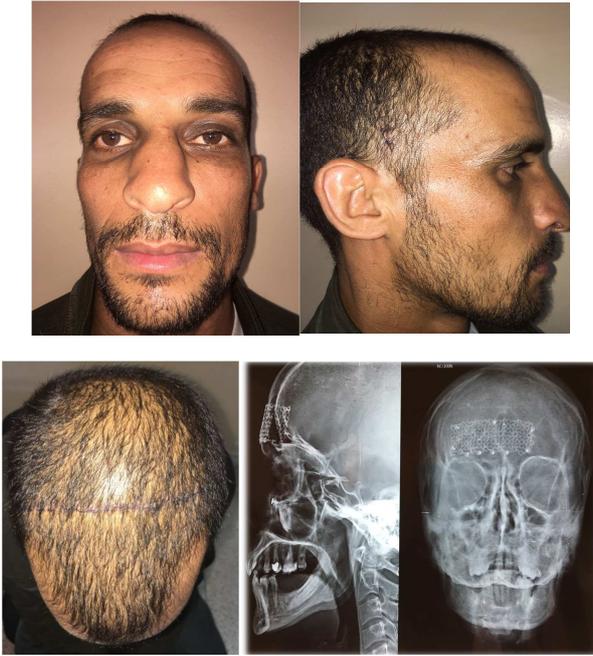


Figure 4. Illustrations of type IV, with frontal reconstruction by a titanium grid, good projection postoperative on face and profile, good healing and grid in place on the control X-ray.

Cranialization and sinus exclusion were performed conventionally as described in the literature [7]. Sinus exclusion of the frontal sinuses was the rule after traumatic rupture of their walls, allowing to separate the sinus and the non-sterile nasal cavity from the intracranial region. It consisted essentially of the mucosal lining of the sinus and was thoroughly removed, to prevent mucopyoceles, mucocele. The nasofrontal duct was packed with pericranium by bone graft mixed with bone powder, followed by reconstruction of the anterior sinus wall. We advocate exclusion without filling like many teams because of the harmful effects of filling (fat melting, muscle necrosis) [7]. A review of the literature showed that some authors are inclined to obliterate the sinus cavity. Various materials such as bone, muscle, fat, proplast, acrylic resin, gelfoam, and methyl methacrylate have been used [6].

There are authors who have reported on the spontaneous closure of the sinus after mucosa removal. Even if this is correct, spontaneous obliteration takes quite some time, during which the risk of infection exists [16, 17].

Cranialization, the purpose of which is to separate the sinus and the non-sterile nasal cavity from the intracranial region and to create a tight barrier between them, was based on the following principles. Complete resection of the posterior wall of the frontal sinus, the mucosal lining of the sinus was thoroughly removed, milling of the bony walls and the nasofrontal duct was carefully obliterated. The sinus was therefore cranialised so the intracranial contents were allowed to occupy the original sinus cavity space [18].

The larger defects loss of dura mater substance was filled by a plasty of sutured or glued epicranium and the other breach by direct sutures or biological glue.

Fragment fixation was done using mini screw plates, steel

wire or sometimes using slow resorption 2.0 sutures.

Admittedly, we have not found consensus in the literature concerning the choice of surgical approaches [19]; but our indications and surgical approaches remain stereotyped and were influenced as in Stiver S. by, dysaesthetic deformation, impactions and embarrasments of clinically-expressed orbital and ethmoidal roofs, obvious obstruction of the nasofrontal duct posterior wall displacement predicting dural laceration and delay [20, 21].

Moreover, we did not find any major complications in our study; but a review of the literature showed they are essentially infectious, and can occur early or late [22].

The sequelae, found in 27.77% of our sample, were essentially functional and aesthetic in relation to complex lesions operated after 15 days (Figure 5. and Figure 6.).



Figure 5. Type IV Ioannides *et al.*, treated urgently within 6 hours with satisfactory aesthetic and functional result, illustrating among others the postoperative benefit of immediate management.



Figure 6. Type IV of Ioannides et al., treated after 15 days with unsatisfactory esthetic result (telécanthus, frontal embarrassment) causing a real change of its identity; illustrating among others the postoperative disadvantage of a late management.

The anosmia which constituted 5.55% of cases of our study is often definitive or of very partial recovery. It can be linked to the initial lesions when they reach the complex frontoethmoid or the explorations of a rhinorrhea [23, 24].

No cases of refractory rhinorrhea, mucocele, or post traumatic meningitis were found on the follow-up of more than one year. As true as it may be, this affirmation deserves to be tempered by a no less classical aphorism: "Dry Fistula is not a closed breach". Moreover, the subsequent risks of fatal meningitis several months or years after the trauma remain in the order of 10 to 30% [2, 12].

In the literature, sequelae would generally result from several factors, including a misdiagnosis, an incorrect lesion assessment, absence of obliteration of the frontonasal canal, or persistence of the sinus mucosa, a complication of the initial treatment, sometimes of serious and complex lesions and especially of a late management beyond 15 days hence the interest of the primary and total rigorous management [22, 23].

5. Conclusion

Fractures of the frontal sinuses are more and more frequent and serious. They involve the vital, functional and aesthetic prognosis of patients, and must therefore require a safe method of management with ways of starting allowing both good security and better exposure. "To leave nothing to a secondary restoration with the often-random result and to neglect nothing" remains the very characteristics of the treatment.

When untreated or insufficiently treated, frontal sinus fractures can present severe long term complications and/or aesthetic deformities.

Conflicts of Interest

The authors declare no conflict of interest.

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