



## Fractures of the frontal sinus: a rationale of treatment

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**SUMMARY.** There is still controversy on the management of frontal sinus fractures, as the optimal method of treatment has not been developed yet. Based on experience with 71 patients we formed a protocol, the basic principles of which are outlined here. In cases of posterior wall fractures the sinus was either cranialised or it was obliterated down to the nasofrontal duct. Anterior table fractures were reduced, defects were reconstructed and the sinus was drained via the nose for 4-6 weeks. Autologous graft material was always used for all reconstructive purposes. Meningitis occurred directly after the operation in 2 patients and a mucopyocele of the sinus with osteomyelitis of the frontal bone 1.5 years postoperatively in another. No further early or long term sequelae originating from the sinus were seen.

Complex naso-fronto-orbital fractures comprise roughly 5% of all facial fractures.<sup>1</sup> The frontal sinus is frequently involved. Due to its proximity to the intracranial structures, inadequate treatment can lead to early or late intracranial infectious sequelae. The most common among the former are meningitis, encephalitis and cerebral abscess.<sup>2-4</sup> Other sequelae are persisting cerebrospinal fluid (CSF) leakage, mucopyoceles, osteomyelitis and meningoencephalocoeles.<sup>3, 5-9</sup> Furthermore, aesthetic deformities can result. The method of ablation of the sinus first described by Riedel in 1926<sup>10</sup> is hardly used any more as it causes extensive disfigurement, which always necessitates a secondary osteoplasty with occasionally unpredictable results.

Management of these fractures is still controversial. The indication, timing, mode of treatment and choice of material in cases of obliteration of the sinus remain debatable as various surgeons opt for different methods.<sup>1, 2, 4, 9, 11-13</sup>

Based on our experience with 71 cases we developed a treatment protocol, the basic principles of which are outlined here.

### Patients and methods

The 71 patients were operated on at the University Hospital K.U. Nijmegen during a 10-year period and at the University Hospital K.U. Leuven during a 1-year period. There were 10 females and 61 males (Fig. 1), the youngest being 11 and the oldest 78 years of age (mean 30.8 years).

All patients were primarily treated. Patients referred to both institutes because of secondary problems, who had been treated elsewhere, were not included in this study.

The anterior wall of the sinus or the anterior wall and the orbital roof were fractured in 45 of the patients. Fractures of both the anterior and the posterior wall

were seen in the other 26 patients. The dura mater was injured in 20 patients.

**Surgical indications and timing.** Nearly all fractures of the frontal sinus were surgically explored and accordingly treated. "Green-stick" fractures of the anterior wall without local soft tissue injuries form an exception and do not need any intervention.<sup>1</sup> Early management (6-12 h post injury), when necessary with intracranial pressure (ICP) monitoring, was the treatment of choice. The indications for placing an ICP monitoring device were up to the neurosurgeon. Late intervention (1-2 weeks post injury) was preferred only in cases of serious neurosurgical contraindications.<sup>14</sup>

**Dura.** The dura was repaired in all 20 cases where it had been injured. Small meningeal lacerations were sutured, whereas larger defects were repaired with lyophilised dura (lyodura) or by means of a pericranial

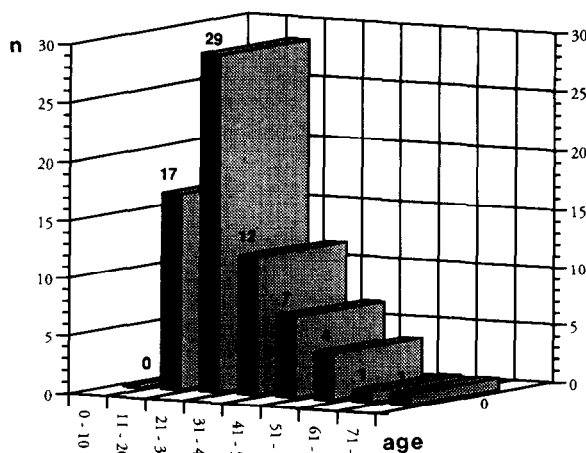


Fig. 1

Figure 1—Age distribution of the 71 patients.



Fig. 2

**Figure 2**—CT-scan of a patient with extensive fractures of the rather well pneumatized frontal sinus. The sinus was cranialised.

flap. If the bony defect was big enough, it was used as the exposure, otherwise a craniotomy was performed.

*Posterior wall.* In cases of a severely comminuted posterior sinus wall the remnants of bony tissue were removed, the mucosal lining of the sinus was thoroughly removed, the nasofrontal duct was obliterated with pericranium and the sinus was therefore cranialised so the intracranial contents were allowed to occupy the original sinus cavity space ( $n = 3$ ) (Fig. 2).

In cases of an extensively fractured posterior wall, the debris, all small loose fragments and the mucosal lining of the sinus were thoroughly removed and the cavity as well as the nasofrontal duct was filled up with cancellous bone harvested from the iliac crest ( $n = 13$ ) (Fig. 3A, B).



Fig. 3

**Figure 3**—(A) Patient with a fractured posterior and anterior wall of the sinus and extensive soft tissue injury. (B) The sinus was obliterated with cancellous bone from the iliac crest after total removal of the mucosa.

In 4 cases with a fractured posterior wall and small dural lacerations the sinus was neither cranialised nor obliterated. The reason for this was the intact mucosa and nasofrontal duct. In the 6 remaining cases of a posterior wall fracture there was no CSF leakage, no displacement of fragments and the mucosa was intact, therefore neither cranialisation nor obliteration were considered.

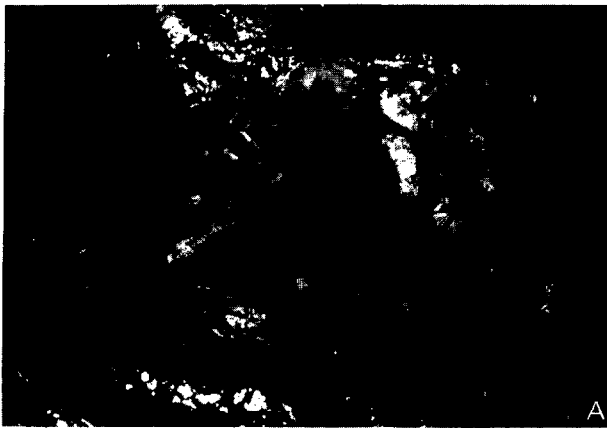
*Anterior wall.* Torn mucosa was excised, the cavity debrided and displaced fragments of the anterior wall were reduced and fixed by means of wires or miniplate osteosyntheses (Fig. 4A, B). Defects were restored by means of cortical plates harvested from the iliac crest or calvarial bone (Fig. 5A, B). If the posterior wall and floor were intact, a silicone drain was placed in the sinus and via the nasofrontal duct it drained the cavity into the nose (Fig. 6). The drain was left *in situ* for 4–6 weeks. Soft tissue lacerations, when present, were closed primarily.

Antibiotics were administered prophylactically in all cases. A broad spectrum antibiotic (usually Amoxicillin, 500 mg 3 times a day for 3 days) was used.

## Results

Two male patients suffered from early postoperative meningitis. It was treated conservatively and both of them recovered completely. A posterior wall fracture had been present in both patients without evident dural lacerations or CSF leakage and the sinus had not been obliterated. There were no other early complications.

The follow-up period ranged from 1–10 years. A small number of patients (10%) was lost to follow-up.



**Fig. 6**

**Figure 4**—(A) Clinical aspect of a patient showing depression of the anterior wall of the sinus. (B) The fragments have been reduced and fixed by means of plate osteosyntheses. **Figure 5**—(A) Clinical aspect of an anterior wall defect. (B) The defect has been reconstructed by means of autologous cortical bone. **Figure 6**—Postoperative lateral X-ray of a patient with a solitary anterior wall fracture. The sinus-nose drain is clearly seen.

One patient, a male, presented 1.5 years after treatment with osteomyelitis of the frontal bone. The sinus was involved by a large mucopycocele, due to mucosal remnants having been left attached to the wall after obliteration of the cavity 1.5 years earlier. The affected bone was removed after extensive debridement of the sinus, and the cavity as well as the nasofrontal duct was obliterated with cancellous bone from the iliac crest. The anterior wall defect was

restored with a cortical plate. The patient has been followed for 2.5 years up to now and has remained free of problems. No other late complications of infectious origin were seen.

The necessary secondary interventions due to aesthetic problems have been analysed in a previous study.<sup>15</sup> As reported there, 14% of the patients needed minor or moderate secondary aesthetic corrections. All of them were due to nose and soft tissue defor-



Fig. 7

**Figure 7**—(A) Defect of the anterior wall of the sinus. (B) The defect has been reconstructed by means of split ribs. (C) The patient 1 month postoperatively. The outline of the left supraorbital area is normal. (D) The patient 1.5 years postoperatively. A moderate deformity of the supraorbital area is clearly seen.

mities. Secondary rhinoplasties and scar revisions restored the aesthetic appearance of these patients. Slight bony irregularities, mostly seen in patients with anterior wall defects reconstructed with split ribs, did not require secondary cranioplasties.

### Discussion

The main goals of the surgical treatment of frontal sinus fractures are:

1. Isolation of the intracranial structures and cessation of CSF leakage.<sup>12</sup>
2. Prevention of early posttraumatic infection or late infectious sequelae such as mucopyoceles, osteomyelitis, intracerebral infections, *etc.* The latter can occur in insufficiently treated patients even years after the primary injury.<sup>2, 7, 16, 17</sup>
3. Restoration of facial aesthetics.

The bicoronal scalp incision offers the best access if overlying soft tissue injuries, when present, are not wide enough. Dural tears can be repaired either via



Fig. 8

**Figure 8**—(A) Patient with a severe injury of the anterior and posterior wall of the sinus and concomitant naso-orbital injuries. (B) The patient 3 months postoperatively. The primary result is acceptable. Minor secondary aesthetic corrections are necessary. (C) Cranial and (D) Lateral aspect of the same patient.

craniotomy or via pre-existing posterior wall defects. In cases of comminution of the back of the sinus with extensive loss of bone, especially in well pneumatized sinuses, cranialisation was preferred. The nasofrontal duct was packed with pericranium. In the majority of cases with a fractured posterior wall with CSF leakage, the dura was repaired, the mucosal lining of the sinus was thoroughly removed, occasionally burred out and the cavity was obliterated down to the nasofrontal duct with cancellous bone from the iliac crest.

A review of the literature showed that some authors are inclined to obliterate the sinus cavity. Various materials such as bone,<sup>13,18</sup> muscle,<sup>11</sup> fat,<sup>19-22</sup> proplast,<sup>23</sup> acrylic resin,<sup>6</sup> gelfoam<sup>24</sup> and methyl methacrylate<sup>25</sup> have been used. The results have varied; in general, however, autologous materials have been far more successful than alloplastic ones. We feel that cancellous bone is the safest of all. Furthermore, when anterior wall defects are reconstructed with cortical plates, the cancellous "filling" offers good support.<sup>26</sup>

There are authors who have reported on the spontaneous closure of the sinus after mucosa removal.<sup>13</sup> Even if this is correct, spontaneous obliteration takes quite some time, during which the risk of infection exists.

In 10 of our patients with a posterior table fracture without displacement the sinus was not obliterated. Two of them developed meningitis. A pre-existing communication between cranium and nasal cavity was misdiagnosed and the situation was underestimated by the surgeon. Now that CT-scans have become a routine examination, chances of inaccurate diagnosis have decreased significantly. The decision, however, not to obliterate a frontal sinus with a posterior table fracture, no CSF leakage, no bony loss and no displacement of fragments remains risky, even if there are no signs of a pneumocephalus on the CT-scans.

The patients who developed meningitis were not treated according to our general principles. The incidence is not really high, however, it justifies obliteration of the sinus cavity in every posterior wall fracture. Furthermore, removal of the mucosa prior to bone "grafting" should be carried out meticulously in order to avoid complications such as those of the patient who developed a mucopyocele of the sinus and osteomyelitis of the frontal bone.

We feel that a broad spectrum antibiotic should be administered prophylactically, as one usually does with contaminated wounds. If an infection occurs, it will be treated accordingly.

Luce<sup>9</sup> postulated that if the patency of the naso-frontal duct can be ensured, no drainage is necessary. We disagree with this point of view. The duct can be patent during the operation despite having been injured; postoperative scarring, however, can cause its late occlusion and eventually formation of a mucopyocele. The aim of the silicone drain is dual: it ensures drainage of the sinus during the early postoperative period and it functions as a "space retainer," preventing scar tissue from occluding the passage.

In the anterior wall all fragments, even the totally detached ones, can be used for the restoration of a fracture "puzzle".<sup>1,27</sup> In cases of loss of bone, one can "bridge" defects by means of iliac crest or calvarial bone. We do not advocate the use of rib as it has been reported by some authors,<sup>1,9</sup> because it can partly resorb, thus leading to secondary deformities (Fig. 7A–D). Alloplastic materials such as methyl methacrylate can cause severe problems and should therefore never be used in primary cranioplasty.<sup>25</sup>

The more one achieves during the first intervention, the less likely it is that secondary corrections will be necessary for an optimal final result<sup>15</sup> (Fig. 8A–D).

Early management of these injuries, usually with intracranial pressure monitoring, is also a factor positively affecting the prognosis of these patients. The findings of *Derdyn et al.*<sup>28</sup> on the timing of operative procedures for craniofacial trauma support this opinion.

Late infectious sequelae can occur several years after the primary intervention.<sup>14,17</sup> Machtens and Klug<sup>17</sup> reported on a patient with a frontobasal fracture who presented 5 years after the primary treatment with osteomyelitis of the frontal bone and

nose. A severe meningitis and encephalitis developed consecutively, which despite intense management led to the patient's death. Long-term follow-up of these patients is mandatory.

In conclusion, untreated or insufficiently treated frontal sinus fractures can present severe long term complications and/or aesthetic deformities. A safe method of management is necessary in order to avoid all of the former. The rationale of treatment outlined here has proved to be safe and satisfactory results were achieved, except for cases which were not treated according to the general principles. Over a period of 10 years serious long-term sequelae have occurred in only one patient. Minor to moderate aesthetic corrections, mostly due to concomitant severe naso-orbital injuries, are sometimes inevitable, no matter how successful the primary intervention has been.

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