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Frontal sinus fractures: principles of treatment and long term results after sinus obliteration with the use of lyophilized cartilage

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SUMMARY. **The most commonly used techniques for frontal sinus obliteration involve the implantation of an autogenous tissue graft: either fat, muscle or bone. Lyophilized allogenic cartilage due to its unique properties, such as the tendency to ossification and resistance to volume reduction, can be used as the material of choice for sinus obliteration.**

A clinical and radiological study of 66 patients operated on for frontal sinus fractures, between January 1 1988 through December 31 1995 was undertaken. Variables recorded included the aetiological factors, the clinical and radiological fracture features with the corresponding treatment modality, the association of frontal sinus fractures with intracranial involvement, the early and late postsurgical complications and the correlation between pre- and postoperative radiological findings. Obliteration of the frontal sinus with lyophilized cartilage chips was performed in 51 (77.3%) patients. The postsurgical evaluation showed no major complications. Revision of the frontal sinus was only required in one patient. The radiological findings verified the progressive calcification of the obliterated sinus.

Allogenic lyophilized cartilage implantation offers distinct advantages in cases of severe frontal sinus trauma:

1. There is nearly unlimited availability of the material.
2. There is no need for a second operation field with the associated potential donor site morbidity.
3. The operation time is reduced due to the avoidance of a second operation on the donor site.

INTRODUCTION

The frontal region is adjacent to anatomically important structures such as the frontal cranial cavity, the frontal lobe, the cribriform plate and the orbits. The presence of the frontal sinus in this already complex area is frequently a confounding factor that must always be addressed when dealing with cranio-maxillofacial trauma.

Solitary, or frequently associated with concomitant craniocerebral lesions, fractures of the frontal sinus are a common problem faced in trauma centres involved in the management of cranio-maxillofacial trauma. The incidence of frontal sinus fractures is estimated to be between 6 and 15% of all cranio-maxillofacial injuries (*Calvert* and *Cairns*, 1942; *May* et al., 1970; *Luce*, 1987; *Onishi* et al., 1989; *Ioannides* et al., 1993).

The outcome of frontal sinus management remains controversial mainly due to the short period of follow-up time. Nevertheless, most authors would accept an open exploration in the presence of a depressed or displaced anterior table fracture, displaced posterior table fracture, or injuries to the nasofrontal duct (*Heller* et al., 1989; *Ioannides* et al., 1993). In these types of frontal sinus fractures the frontal sinus obliteration which is defined as 'obliteration of the frontal sinus cavity while maintaining or restoring intact bony walls' has been evolved as a successful alternative to radical ablative procedures (*Mickel* et al., 1995).

The most commonly used techniques for frontal sinus obliteration involve the implantation of an autogenous tissue graft: either fat, muscle, or bone (*Bergara* and *Itoiz*, 1955; *Montgomery* and *Pierce*, 1963; *Nadell* and *Kline*, 1974; *Donald* and *Bernstein*, 1978; *Knauff*, 1963; *Merville* and *Derome*, 1978). The method of spontaneous osteoneogenesis (*MacBeth*, 1954) or the use of synthetic bone substitutes such as hydroxyapatite, have been also reported (*Rosen* and *Nachtigal*, 1995). These techniques sometimes fail because of tissue absorption, infection, and implant rejection (*Bordley* and *Bosley*, 1973; *Hardy* and *Montgomery*, 1976; *Donald* and *Ettin*, 1986). Even ignoring the morbidity of the donor site, the prolongation of the operation time has also to be pointed out, especially in critically ill patients with severe frontal sinus trauma which is often associated with intracerebral lesions.

Allogenic lyophilized cartilage has been primarily used in reconstructive surgery, mainly for the restoration of contour defects (*Sailer*, 1976). Its unique properties, namely the tendency to ossification and the resistance to volume reduction (*Sailer*, 1983) has led to the utilization of the material with growing success in craniofacial surgery for the obliteration of the dead space occurring after fronto-orbital advancement or hypertelorism correction (*Sailer* and *Landolt*, 1987). Lyophilized cartilage for obliteration of the frontal sinus in primary trauma has been used since 1987 and reported first by *Sailer* and *Grätz* (1991). The clinical

experience gained over this period has been very promising, so that allogenic lyophilized cartilage has been established as the material of choice when obliteration of the exposed frontal sinus is needed.

This study presents the clinical and radiological evaluation of patients operated on for frontal sinus fractures. The goal is the categorization of the fracture patterns and the corresponding therapeutical modalities and especially the evaluation of long-term results of our obliteration technique using allogenic lyophilized cartilage.

PATIENTS AND METHODS

Sixty-six patients have been treated surgically in the Department of Cranio-Maxillofacial Surgery of the University Hospital of Zürich between January 1 1988 and December 31 1995. The patient population consisted of 52 (78.8%) male patients and 14 (21.2%) female patients. The mean age at operation was 33.5 years whereas the patient population age ranged from 6–78 years. The follow-up time ranged from 18 months to 9 years with an average of 56.7 months. All patients were pre- and postoperatively evaluated clinically and radiologically with plain X-rays and computed tomography (CT) scans. In four patients, magnetic resonance imaging (MRI) scanning was additionally performed.

Variables recorded included the aetiological factors, the clinical and radiological fracture features and the corresponding treatment modality, the association of frontal sinus fractures with intracranial involvement and the early and late postsurgical complications.

The rib cartilage utilized is obtained through the Institute of Forensic Medicine, University of Zürich from selected human cadavers, victims of accidents up to 30 years of age. It must be ensured that there was no infection, generic disease, HIV, hepatitis, malignant tumours or any neurological disease before the death.

The processing of the rib cartilage is performed according to *Sailer* (1983) by a special lyophilization technique. At the end of the procedure, the material is gas sterilized, degassed and stored. Rehydration takes place in distilled water containing penicillin and streptomycin or any antibiotic of choice according to an antiobiogram. The production of the material in our department is free of costs. Lyophilized cartilage can be supplied by several tissue banks in the US and elswhere.

Therapeutic concept and surgical technique

The management and the surgical treatment of a fractured frontal sinus depends on the type of fracture (solitary or complex; open or closed) and the presence of concomitant craniocerebral lesions. Treatment should not be delayed and should aim at both neurosurgical and primary maxillofacial repair, the latter being based upon open reduction and internal osteosynthesis of all fragments.

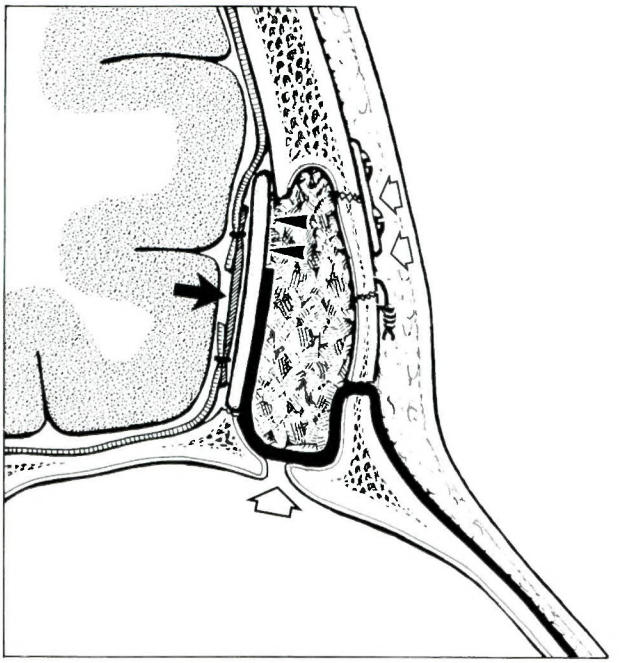


Fig. 1 – Drawing of frontal sinus obliteratation with lyophilized cartilage. Dura is covered with a pericranium patch (arrow) and the posterior wall is reconstructed with lyophilized cartilage slices (double arrows). The frontonasal duct is occluded with a pedicled pericranium flap (white arrow). The reconstructed sinus is filled with lyophilized cartilage chips. Fixation of the anterior table is by means of internal osteosynthesis (double white arrows).

Closed, solitary, undisplaced fractures of the anterior table alone are seen; closed displaced anterior wall fractures are preferably stabilized using mini- or microplates. Open or depressed fractures of the anterior wall or fractures of both sinus walls and frontonasal duct involvement have to be explored further. The frontal sinus area is exposed using a coronal incision without damaging the pericranium. After elevation of the galeocutaneous flap, a subpericranial dissection is performed whereby the pericranium remains pedicled on its caudal border. This extended pedicled flap should be of sufficient length to achieve a watertight separation of the cranial base (in cases of associated frontal skull base injury) and occlusion of the nasofrontal duct (Fig. 1). Then the complete mucous lining of the frontal sinus is removed using magnification loupes. If the posterior wall is fractured too, the displaced bony fragments are removed thus promoting an appropriate approach to the anterior skull base. The pedicled pericranium flap is rotated into the sinus to seal off the frontonasal duct. In cases with dural exposure or CSF leak, a pericranium patch is used for the watertight separation of the brain

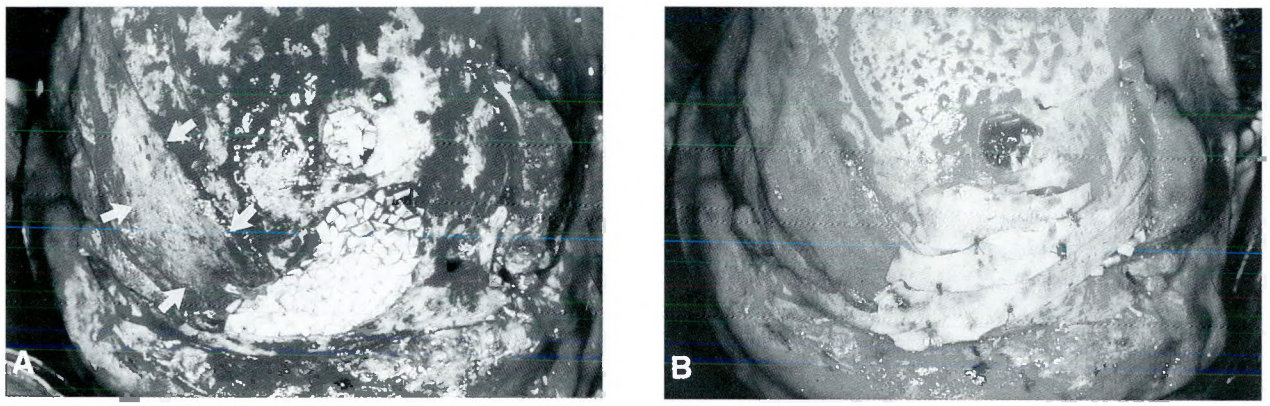


Fig. 2 – Obliteration of the reconstructed frontal sinus. The sinus cavity is obliterated by chips (a) after a pedicled pericranium flap (see white arrows) was inserted into the frontal sinus floor for sealing of the frontonasal duct. The missing anterior sinus wall was reconstructed using lyophilized cartilage slices (b).

Table 1 – Aetiology of FSF

Road traffic accident	46 pts	(69.7%)
Sport, domestic accident	11 pts	(16.7%)
Work accident	7 pts	(10.6%)
Gunshot wound	2 pts	(3.0%)

Table 2 – Fracture distribution

Type of fracture	Patients	
1 'Through-and-through' (skin to anterior cranial fossa)	20 pts	(30.3%)
2 Anterior and posterior walls	15 pts	(22.7%)
3 Anterior wall	18 pts	(27.3%)
4 Posterior wall	1 pts	(1.5%)
5 Frontonasal duct	8 pts	(12.1%)
6 Associated with bone defect	4 pts	(6.1%)

cavity. Additional fixation of the pericranium patch to the dura can be achieved by the use of fibrin glue (*Grätz* et al., 1994). If the posterior wall is severely comminuted, the bony fragments are removed and the wall is reconstructed with lyophilized cartilage slices. Then the whole sinus is packed with lyophilized cartilage chips embedded in fibrin glue (Fig. 2A). The anterior table fragments are carefully repositioned and stabilized with wires, microplates or resorbable plates. If a frontal bone defect coexists, sheets of lyophilized cartilage for smaller defects, or lyophilized cartilage chips combined with split thickness calvarial bone in cases with extensive frontal bone loss, are used for the reconstruction of the forehead contour (Fig. 2B).

RESULTS

Aetiology

The majority of frontal sinus fractures (FSF) was sustained by young adult males involved in vehicle accidents, confirming the statement that the frontal sinus fracture is a 'morbidity of the young male motor vehicle driver' (*Wallis* and *Donald*, 1988). Table 1 classifies the aetiology of frontal sinus fractures.

Classification of FSF and fracture distribution

There is not a unanimously agreed classification of frontal sinus fractures, and most of the ones already proposed are based on clinical experience (*Rowe* and *Killey*, 1968; *Stanley*, 1989). A classification based on both clinical and radiological findings is submitted. The main parameters are the bony wall damage and the radiological evidence of frontonasal duct involvement (Table 2). All 51 cases with obliteration with lyophilized cartilage showed partial or total calcification (Fig. 3A, B).

Intracranial involvement

Suspected cerebrospinal fluid (CSF) leakage may be difficult to confirm in the presence of the blood and mucus that commonly accompany these injuries. CSF rhinorrhoea suggests a through-and-through fracture of the posterior table or floor of the frontal sinus. But dural tears may be also present without CSF rhinorrhoea if the sinus outflow is obstructed (*Newman* and *Travis*, 1973). Thirty-five patients (53%) presented clinically with a CSF leak at the first examination, 28 (42.4%) without, and in three (4.6%) patients no definitive diagnosis could be made.

Apart from CSF leakage, direct intracranial damage has been revealed in 24 (36.4%) patients. However, CSF leakage and intracranial damage cannot be attributed directly to the frontal sinus fracture due to the coexistence of severe skull base and/or naso-orbito-ethmoid lesions (Table 3).

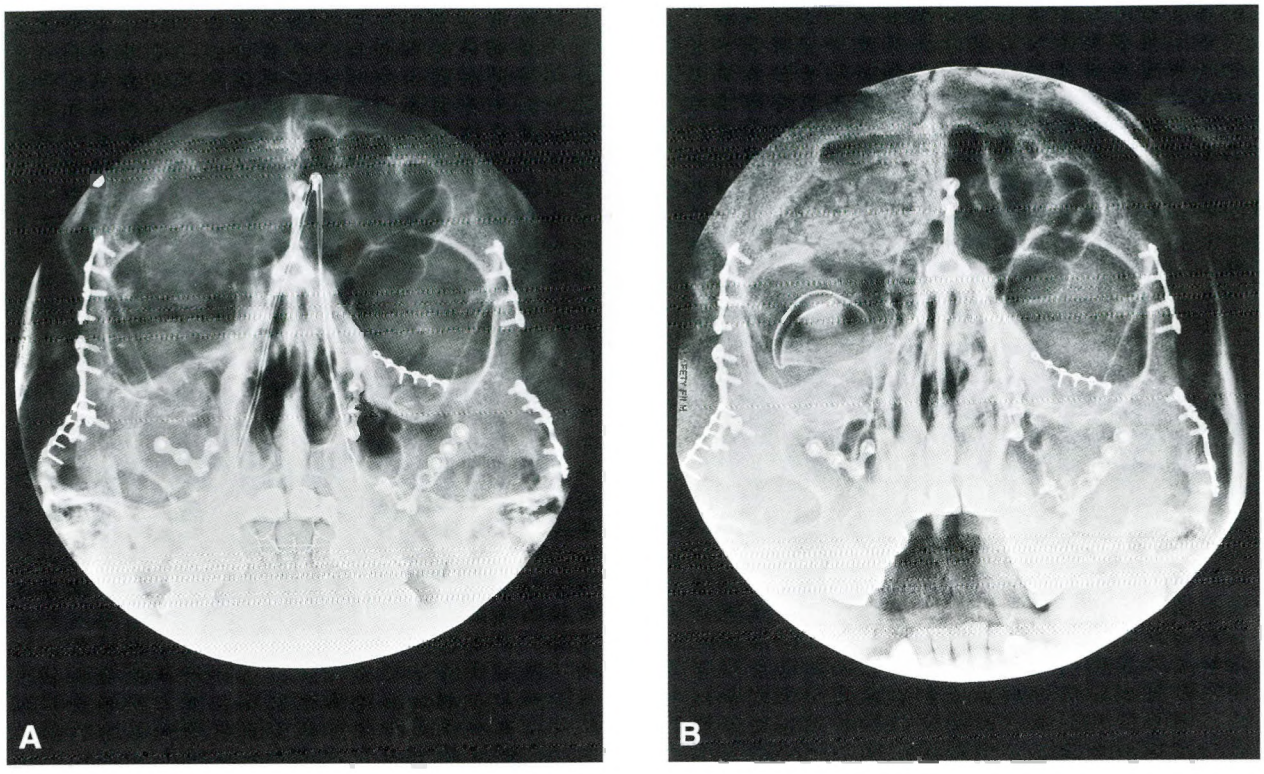


Fig. 3 – Case of midface fracture with fronto-naso-ethmoidal involvement and filling of the right frontal sinus with lyophilized cartilage chips: condition immediately after treatment (A) and 2 years postoperatively (B); the calcification of the obliterated right frontal sinus is clearly demonstrated.

Table 3 – Type of fracture and intracranial involvement

Type of fracture	CSF leak	Intracranial lesion	Pneumocranium
Type 1 (20 pts)	17 pts (85.0%	18 pts (90.0%)	20 pts (100%)
Type 2 (15 pts)	3 pts (20.0%)	2 pts (13.3%)	14 pts (93.3%)
Type 3 (18 pts)	4 pts (22.2%)	–	–
Type 4 (1 pts)	1 pts (100.0%)	–	1 pts (100)
Type 5 (8 pts)	7 pts (87.5)	1 pts (12.5%)	1 pts (12.5%)
Type 6 (4 pts)	3 pts (75.0%)	3 pts (75.0%)	3 pts (75%)

Pneumocranium

CT scans are used as the imaging method of choice supplying as much, if not more, information than any other investigation regarding not only the frontal sinus fracture but also associated lesions of the anterior skull base. The preoperative examination included axial CT scans in both soft and bone window. Table 3 illustrates the correlation between the different types of fractures and the presence of a pneumocranium.

Surgical results

The patient population was divided into three groups according to the surgical procedures performed (Table 4). The first operative group included those patients of type 3 frontal sinus fractures with closed, displaced anterior wall fragmentation. In these patients (n = 15) the surgical intervention consisted only of the fixation of the bone fragments. The second group included patients (n = 30) with complex sinus fractures (type 2, 3, 4, 5, 6 or combinations of them) operated on to obliterate the frontal sinus with lyophilized cartilage chips after previous eradication of the sinus mucosa and frontonasal duct obstruction, with a pericranium flap.

Table 4 Types of operations

• Osteosynthesis of the anterior wall	15	(27.7%)
• Obliteration of the sinus cavity with lyocartilage	30	(45.4%)
• Obliteration of the residual sinus space with lyocartilage	21	(31.8%)

The last group consisted of those patients (n = 21) with concomitant intracranial damage (type 1 and type 6). In the latter, after removal of the posterior wall fragments, the dura was sealed off with a pedicled pericranium flap and the posterior wall was reconstructed with lyophilized cartilage slices. The former sinus cavity was filled with lyophilized cartilage chips embedded in fibrin glue. In cases with

Table 5 – Postsurgical complications

Early		Late	
Frontal pain (slight or moderate)	6 pts (9%)	Infection: (required surgery)	1 pt (1.5%) 1pt
Contour deformity (required surgery)	3 pts (4.5%) 2 pts		
CSF leak: (ceased spontaneously)	1 pt (1.5%)		

extensive violation of the frontal lobe and brain loss, the tissue defect was obliterated with lyocartilage chips in order to eliminate the resultant dead space, without reconstructing the posterior wall.

Complications

There were no intraoperative complications in our series (Table 5). An early complication occurring within the first 6 months (*Rohrich* and *Hollier*, 1992) was frontal pain presented by 6 patients (9%) in the form of a headache which did not persist. None of them required regular medication. In three patients (4.5%), frontal contour deformity was seen. This was particularly the case in patients with extensive bone loss, and in two of them a secondary reconstruction was performed. CSF leakage was noted in one patient (1.5%) in the immediate postoperative period. In this case, the CSF leak stopped spontaneously, so that the leak site remained undocumented. In one patient (1.5%) late infection in the supraorbital region occurred 9 months after surgery. After initial unsuccessful treatment with antibiotics, a revision of the obliterated sinus was undertaken. A small bone sequestrum of the anterior sinus wall was removed with the non-calcified part of the lyophilized cartilage chips. Lyophilized cartilage was again implanted in the residual sinus. After 3 years follow-up the patient remains free of symptoms and the follow up CT scans illustrated the uneventful postoperative course. Major complications such as death, meningitis, brain abscess, mucocele or mucopyocele have not been recorded.

DISCUSSION

The outcome of frontal sinus fracture management remains controversial because of the relative rarity of frontal sinus fractures, the different treatment modalities and the short follow-up time.

Calvert and *Cairs* (1942) reported 1731 cases of head injuries, of which 37% sustained fractures of the cranial vault or base, but only in 15% of them were the frontal and ethmoidal sinuses involved. A high proportion (70%) of these fractures were complex, and 35% of the patients suffered from unilateral or bilateral anosmia. *Luce* (1987) reported that 8% of all facial fractures involving the frontal sinus mainly occurred as a result of a motor vehicle or pedestrian accident. *Wallis* and *Donald* (1988) found also that the majority of frontal sinus fractures were sustained by young adult males (84% of the study group) involved in motor vehicle accidents. Our results are in agreement with those of the literature showing a predilection for males (78.8%). The average age (33.5 years) and the aetiological factors seem to justify the statement that 'frontal sinus fractures are a disease of the young male motor vehicle driver' (*Wallis* and *Donald*, 1988).

Frontal sinus fractures are usually classified according to the bony wall and/or the frontonasal duct involvement (*Rowe* and *Killey*, 1968; *Stanley*, 1989; *Wallis* and *Donald*, 1988). Frontal sinus fractures, when the bony walls are missing, have not previously been classified although they pose a therapeutic dilemma due to the increased risk of postoperative complications (*Donald* and *Ettin*, 1986). The classification which we propose may lead to a better classification of the preoperative findings and the consequent surgical schedule which differs in cases of extensive bone loss.

Fifty-nine percent of our patients sustained fractures involving both the anterior and posterior walls; over half of these fractures presented with either dural laceration or anterior cranial fossa involvement. The incidence of complex frontal sinus fractures in the literature ranges between 26% (*Onishi* et al., 1989) to 76% (*Wallis* and *Donald*, 1988). Our results are in concordance with those of *Stanley* and *Becker* (1987); they found an incidence of 56% in their series. Only *Wallis* and *Donald* (1988) reported higher incidence of severe frontal sinus fracture (76%). Missing bone (greater than 50% of the sinus walls) was documented in 6.1% of our patient population. This incidence is lower than this reported by *Wallis* and *Donald* (1988), which ranged as high as 17%. The significance of this in regard to the problems engendered by fat grafting has been demonstrated by *Donald* and *Ettin* (1986).

Thirty-five patients (53%) of our study group presented with CSF leakage at the first examination, 28 (42.4%) did not have it and finally, in four patients (4.6%) no definitive conclusion could be drawn *Newman* and *Travis* (1973) found only 8% of their patients had associated dural lacerations and CSF rhinorrhoea which required operative closure of the dura. However, *Sataloff* et al. (1984) found in their series that 57% had fragmentation of the inner table and 35.7% dural laceration. *Hybels* and *Weimert* (1979) found that intracranial injuries did not occur as often as might be expected. In their series, 13% of the patients suffered permanent brain injuries. In the patient population studied by *Luce* (1987), 36% were complicated by CSF leakage at the initial examination. According to *Wallis* and *Donald* (1988), 44% of their patients showed the presence of either brain or

CSF in the wound. CSF leakage and/or direct intracranial damage was noted in 26% of the patients of *Onishi* et al. (1989). Finally, dura mater was exposed in 28% of the patients examined by *Ioannides* et al. (1993). Intracranial damage was revealed in 23 (34.8%) of our patients. However, it has to be emphasized that CSF leakage and intracranial damage cannot be attributed directly to the frontal sinus fracture, as many patients had concomitant skull base fractures. Although direct correlation between frontal sinus fractures and severity of the intracranial involvement presenting as CSF leakage and/or damage to the frontal lobes cannot be confirmed due to the concomitant skull injuries, it is interesting to see that even in cases of anterior sinus wall fragmentation, a CSF leak (in our series, 22%) has to be confirmed or excluded respectively.

Axial CT scans most clearly confirm the presence of such depressed fractures, which are often overlooked clinically because the forehead soft-tissue depression is filled by oedema and haemorrhage (*Olson* et al., 1992). In 39 patients (59.1%) of our series, a frontal pneumocranium has been detected. This was the case in patients with 'through-and-through' injuries and fractures of both walls, with the exception of one single case with an isolated, undisplaced posterior table fracture. Pneumocranium was also detected in a frontonasal duct fracture with concomitant skull base fragmentation. However, CT scanning has not been particularly helpful in the accurate determination of the magnitude of displacement or comminution, especially of the posterior wall. Our data are in agreement with the literature overview, whereas CT scanning is unanimously considered the imaging method of choice for the visualization of severe craniofacial trauma (*Harris* et al., 1987; *Luce*, 1987; *Helmy* et al., 1990; *Olson* et al., 1992; *Grätz* et al., 1994; *Som* and *Brandwein*, 1996).

In light of devastating complications such as mucocele, mucopyocele, osteomyelitis, meningitis or even brain abscess (*Newman* and *Travis*, 1973) the surgical modalities applied in the treatment of frontal sinus fractures became more agressive, aiming at one-stage management of the sinus trauma. The better imaging of the injured area by CT scans, and the evolution of osteosynthesis systems providing stable fixation of the denuded bone fragments played a decisive role.

While fat obliteration is the most popular obliterative procedure to date, it is not without complications; failure rates up to 25% have been reported (*Bordley* and *Bosley*, 1973). *Hardy* and *Montgomery* (1976) reviewed 250 patients treated by an osteoplastic frontal sinusotomy with a median follow-up of 8 years. Their overall complication rate was 18%. A categorization of the operative and postoperative complications revealed a postoperative infection rate of the abdominal wound of up to 5.2%, a 3% incidence of acute postoperative infection with necrosis of the implanted fat, and a 3% incidence of recurrent chronic sinus infection. The latter series indicates the potential significance of the donor site in contributing to postoperative morbidity. This aside, it has to be stressed that in cases of severe frontal sinus trauma where significant portions of one or both walls are missing, the fate of fat graft seems to be rather equivocal (*Donald* and *Ettin*, 1986).

Throughout the years there have been intermittent reports on the use of cancellous bone for obliteration of the frontal sinus and reconstruction of frontal bone defects (*Joannides* et al., 1984, 1993; *Wolfe* and *Johnson*, 1988; *Shumrick* and *Smith*, 1994). However, it has been demonstrated experimentally that in cases of endochondral bone grafting (i.e. illiac bone) there is only maintenance of 50% of endochondral bone volume (*Zins* and *Whitaker*, 1983). Additionally, maximal loss of volume occurs when there is incomplete bone to bone contact and the fact that a certain amount of resorption is inevitable in nonfunctional areas (*Whitaker*, 1989).

The implantation of autogenous muscle was found (*McNeil*, 1967) to be as effective as fat in the obliteration of the frontal sinus.

As far as the osteoneogenesis method is concerned, *Bordley* and *Bosley* (1973) reviewed 100 consecutive patients operated on by the MacBeth procedure, with follow-up ranging from 5 months to 13 years and radiographic evidence of incomplete sinus obliteration in 7% and a 3% incidence of mucocele formation.

Obliteration of the frontal sinus has also been reported with the use of hydroxyapatite or ionomer cement (*Rosen* and *Nachtigal*, 1995; *Weber* et al., 1997). However, these references suffer from lack of a documented series and a long follow-up time.

Donald and *Bernstein* (1978) described the cranialization technique for frontal sinus fracture management. This technique could be the method of choice if the brain expansion could really fill the remaining residual space. In cases with comminuted fractures with displacement of the anterior and posterior walls and laceration of the frontal lobe, cranialization is mandatory, because of the expansion of the oedematous brain. In cases without brain oedema the problem of the resultant dead space has been focussed in craniofacial surgery when adults with craniofacial anomalies undergo frontofacial advancements. It is well known that transcranial facial and fronto-orbital advancements leave a large frontal extradural space, sometimes in free communication with the paranasal air sinuses, which is a potential site of infection (*David* and *Cooter*, 1987). In 1987, *Sailer* advocated the use of allogenic lyophized cartilage for the closure of large defects in the cranial base area after hypertelorism correction (*Sailer* and *Landolt*, 1987). Four years later the same author (*Sailer* and *Grätz*, 1991), after the promising clinical outcome of the craniofacial procedures, proposed the use of lyophilized cartilage for the obliteration of the damaged frontal sinus

and the reconstruction of concomitant bone defects in the skull base area.

Cartilage as a graft material has unique properties. It virtually never resorbs, regardless of whether it is applied as an inlay or onlay (*Sailer*, 1983; *Whitaker*, 1989).

Preserved cartilage allografts produce satisfactory results according to some investigators. *Schuller* et al. (1977) reported a 3-year study of irradiated cartilage allografts used in facial contour restoration in which graft resorption was seen in only 1.4%. Conversely, *Sailer* (1983) noted that irradiated cartilage resorbs unpredictably due to structural modifications of the material after irradiation. Moreover, using monkeys as the experimental model, he noted the high resorption tendency of fresh cartilage allografts, explained as a host reaction, absent in cases with lyophilized cartilage. The fact is that under experimental conditions there were no signs of infection or abscess formation in the lyophilized cartilage graft attributed to the absorption of large quantities of antibiotics during the rehydration of the material (*Sailer*, 1983; *Puelacher* et al., 1990). *Sailer* concluded that allogenic lyophilized cartilage undergoes osseous substitution from the base upwards if lying on bare smooth bone. Subperiosteally placed lyophilized grafts ossify more quickly than those placed subcutaneously; in the first case, acquired osseous fixation could be experimentally proved after 23–50 days; within a year the implanted material had practically integrated with the basal bone.

Lyophilized cartilage can be combined with autogenous bone as is the case in extensive bone defects. This composite graft as proved experimentally, presents a tendency to early incorporation, revascularization, resorption of the freeze-dried component and simultaneous formation of bone ossicles that continue to remodel and form mature lamellar bone (*Kline* and *Rimer*, 1983). Our clinical and radiological observation of patients operated on for large bone defects of the anterior sinus wall is in agreement with these remarks.

Complications that have been related to frontal sinus fractures include: acute and chronic sinusitis, mucocele, mucopyocele, osteomyelitis, meningitis and even brain abscess (*Bosley*, 1972). The most common complication seen in our series was frontal pain (9%), followed by contour deformity (4.5%). CSF leakage has been noted in one patient. Revision of the frontal sinus was needed in one patient as well. The incidence of complications in our series is low compared with other references, with the exception of persistent frontal pain (*Hardy* and *Montgomery*, 1976; *Donald*, 1982; *Wallis* and *Donald*, 1988; *Ioannides* et al., 1993). Bone-banking and bone (or cartilage) transplantation involve the problem of potential HIV transfer from tissue donor to recipient. The possibility of infectious complications following bone or cartilage grafting (HIV and AIDS) has to be mentioned. The estimated risk of HIV-infection after allogenic bone transplantation is 1:1.7 million (*Buck* et al., 1989). In the same fashion, every patient who may receive a bone or cartilage graft has to be informed of this risk.

Finally, it should be mentioned that allogenic lyophilized cartilage implantation offers distinct advantages:

1. There is almost no limit to the availability of allogenic cartilage, although in practice allogenic cartilage procurement may be associated with considerable difficulty, for example, a lack of donors or of consent for cartilage harvesting.
2. There is no need for a second operation field. Complications such as infection, pain or painful scars at the donor site can be avoided.
3. The operation time is reduced due to the avoidance of the second operation at the donor site.

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