Use of titanium Mesh in comminuted fractures of frontal sinus anterior wall

L'uso delle Mesh in titanio nelle fratture comminate della parete anteriore del seno frontale

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Summary
The personal experience with the surgical treatment of reduction and fixation of comminuted fractures of the anterior wall of the frontal sinus is reported. Cosmetic results were examined with regard to patients' degree of satisfaction on a 0 to 2 scale and nasal function assessed via rhinoscopy and nasal endoscopy during clinical follow-up, in the course of which the integrity and functionality of the supraorbital and facial nerves were evaluated. All patients were satisfied, on the whole, with the aesthetic result, with 0-degree satisfaction (no deformity compared with their condition prior to the injury). The operations were performed between the 2nd and 7th post-injury day. The importance of the preoperative clinico-radiological work-up is stressed, with particular regard to the detection of simultaneous involvement of the inferior and/or posterior wall, and to the choice of surgical approach. The evolution of the surgical techniques in the treatment of frontal sinus fractures is discussed. With reference to the new means of fixation, in cases of comminuted fractures of the anterior wall, titanium mesh is preferred. In the Authors' opinion it combines excellent fixation with easy adaptability (cosmetic results are good) without requiring in the majority of cases, autologous bone grafts.

Introduction
The anatomical integrity of the frontal sinus, as the border region between the splanchnocranium and the neurocranium, is a decisive factor not only in preserving the original facial anatomy, but also in maintaining the protective function of the neurocranium and anterior cranial base. For this reason, fractures of one or more walls of the frontal sinus may determine not only facial asymmetry, but also functional alterations, resulting in recurrent infections and possibly endocranial complications. Overall, they account for 5-12% of maxillofacial traumas and are often associated with intracranial or multisystemic damage. The cause of injury is a car or motorcycle accident in 71% of cases, an assault in 10% of cases, an accident at work in 9% of cases, a gunshot wound in 6% of cases and a sports injury in 4% of cases.

The primary aim of surgical treatment is to restore the normal anatomy by reduction and stabilisation of the fracture and to prevent meningoencephalic infections that can be serious. Aim of the present investigation was to analyse retrospectively the cosmetic and functional results of treatment of frontal anterior wall sinus comminuted fractures and in relation to the materials used, stressing the usefulness of titanium mesh, which has over-
come some of the technical limitations imposed by the use of metal wire and mini- and microplates.

**Patients and Methods**

The retrospective analysis involved 13 patients (9 males, 4 females) with comminuted fractures of the anterior wall of the frontal sinus, observed in our clinic between January 1996 and December 2001. The patients ranged in age from 19 to 61 years, mean 43.5. Of these, 11 were available for follow-up. Observations were carried out on 8 males and 3 females for a follow-up period ranging from 12 to 48 months, mean 24. The cause of injury in 5 patients was a car accident; in 2, a motorcycle accident; 3 had been victims of an assault, and 1 had had a sports injury. After polyspecialist clinical evaluation, the patients underwent diagnostic imaging (axial and coronal computed tomography (CT) images, antero-posterior and lateral X-rays). In 10 out of the 11 patients, a bitemporal coronal surgical approach was chosen, while a lacerated and contused frontal wound associated with the fracture was exploited in the remaining case. Removal of the intrasinus mucosa was always carefully carried out, including toilette of the lateral, posterior, inferior, orbital and ethmoidal recesses. The posterior wall of the frontal sinus was then carefully assessed (even if free lesions at X-ray), together with the inferior wall, to confirm the integrity of sinonasal drainage. Fixation was achieved with metal wire in 2 cases, with mini- or microplates in 2, and with titanium mesh in the remaining 7. In the latter 9 cases, and in particular in those in which titanium mesh was used, the bone fragments were removed and reassembled with the fixation medium. The “puzzle” was then repositioned on the cranial theca, where it was secured.

All patients underwent surgery between the 2nd and 7th post-injury day. Outcome of the surgical procedure was evaluated with standard radiology (head X-ray) and, in selected cases, also by CT. The cosmetic results were evaluated using a patient satisfaction scale of 0 to 2 (0, no deformity when compared to the preoperative situation; 1, slight deformity; 2, marked deformity). Nasal function was evaluated through
rhinoscopy and nasal endoscopy (presence or absence of intranasal obstruction). Supraorbital nerve function was also evaluated (to rule out the presence of paraesthesia, dyseaesthesia, or anaesthesia of the supraorbital region), as was that of the facial nerve. The possible onset of complications was considered both in the immediate post-operative period and during follow-up.

Results

All 11 patients, in the follow-up, presented 0 level satisfaction (no deformity when compared with their condition prior to injury). Axial and coronal CT images all showed good realignment of the frontal anatomy. Nasal function evaluated by means of anterior rhinoscopy and endoscopy showed no obstruction or intranasal alteration in 10/11 patients treated; in only one patient there was an obstruction of modest entity. In none of the 11 patients, was there any deficit of the supraorbital and facial nerves. In the immediate post-operative period (2 weeks after the procedure), an infection of the surgical wound was found in one patient (the only case in which surgical access was effected through the cutaneous wound determined by the injury), which was successfully treated with antibiotic therapy. In none of the 11 patients, were there any intracranial complications (meningitis, rhinoliquorrhoea, cerebral abscess, pneumoencephalus) or extrusions of the means of fixation.

Discussion

The surgical treatment of frontal sinus fractures follows a therapeutic algorithm essentially based on the specific site of the lesion. Fractures in this area, with reference to the involvement of one or more walls and to whether or not the naso-frontal duct has suffered damage, are classified as:

- anterior wall fractures;
- posterior wall fractures;
- inferior wall fractures (involving the naso-frontal duct);
- anterior and posterior wall fractures;
- “through and through” fractures (from the skin to the anterior cranial fossa).

The development of biomaterials and new techniques in the field of craniofacial sinus surgery has allowed considerable, constant progress in surgical treatment. Reidel Schenke was the first to describe the ablation of the anterior wall of the frontal sinus. In 1921, Lynch perfected external frontoethmoidectomy and was the first to insert a catheter in the sinus for prolonged drainage, preserving the frontal bone. In 1955, Bergara and Itoiz proposed the pericranial flap which replaced the anterior sinus wall and solved the cosmetic problem. Goodale and Montgomery added a further step by removing the mucosal content of the sinus and obliterating the same with autologous fat, noting, together with Stanley, a reduced rate of infection even with damage to the nasofrontal duct. Later, other materials were proposed for the obliteration of the sinus: bone, muscle, fascia. In 1978, Donald and Bernstein initiated the cranialisation of the frontal sinus, with prolapse of the brain into the sinus cavity in cases of posterior wall fracture, nonetheless reserving this approach to cases of massive damage of the posterior wall. With the exception of emergencies comprising lesions of neurosurgical pertinence, in our opinion, it is advisable to perform the operation within 24-72 hours of the injury (compatibly with the general condition of the patient), in order to reduce the probability of short- and long-term complications such as meningitis, cerebral abscesses, rhinoliquorrhoea, mucopyocele and periorbital infections.

The bitemporal coronal approach is preferred by most Authors, including ourselves, as it not only allows excellent visualisation of the entire frontal sinus, of fundamental importance in anterior wall comminuted fractures, and also determines minimal cos-
metrical sequelae or none at all. Instead, we reserve the translesional approach to small-sized, non-comminuted fractures. We have no experience with the supraclival or butterfly approaches which, in our opinion, may easily cause lesions of the supraorbital nerve, which result in paraesthesia and anaesthesia of the frontal region, besides involving a higher risk of cosmetic sequelae.

In treating cases of posterior wall fractures, those with bone fragment displacement should be distinguished from those with linear fractures of the posterior wall. In the former, in fact, the fragments should be removed through the anterior sinus wall, followed by cranialisation of the same, via meticulous removal of the mucosa, packing of the nasofrontal duct and remaining intrasinus dead space. A variety of materials have been proposed for this purpose: autologous bone, fascia, muscle, fat, freeze-dried cartilage or allografts, or none at all. Instead, we reserve the autologous bone grafts.

In linear fractures of the posterior wall, on the other hand, once the fracture has been reduced through the anterior wall, the surgeon may opt for cranialisation of the sinus or selective demucosation alone, with appropriate restoration of duct patency, which can be achieved by inserting a 5-9 mm silicon drain, to be removed after 15-20 days.

In fractures involving the inferior wall of the sinus and, consequently, the nasofrontal duct, surgical treatment should be aimed at restoring duct patency, which may be achieved by inserting a silicon tube or effecting a nasal contra-aperture with tamponage and anterior removal of the mucosa.

Anterior wall fractures may present as linear, depressed or comminuted, with or without the loss of matter, and if not reduced, can lead to permanent cosmetic deformity. Surgical treatment of comminuted fractures is particularly difficult, as the minute dimensions of the bone fragments, at times, do not allow fixation with wire and microplates, as it is an excellent means of stabilisation even in those cases in which partial loss of matter has occurred. Even if titanium Mesh was first used during the Vietnam War, it is only in these last few years, for the improvements in reducing its initial rigidity and increasing its resistance and malleability, its use in maxillofacial fractures has become more widespread.

The advantages of employing titanium Mesh consist, not only in the optimal stabilisation of the fracture, but also in its excellent biocompatibility and in the minimal inflammatory reactions it provokes, as well as the ease with which it adapts to different shapes; furthermore, titanium produces only minimal artefacts on MRI and CT.

In cases of comminuted fractures of the anterior wall of the frontal sinus, the small bone fragments should, in our opinion, be individually fixed to the mesh with titanium screws and, in agreement with other Authors, we suggest that the "puzzle" be assembled on the operating table and then secured to the intact rims of the frontal bone so as to reduce the need for autologous bone grafts.

In conclusion, comminuted frontal sinus fractures of the anterior wall require, in our opinion, wide surgical exposure by means of a bitemporal coronal incision, and titanium Mesh should, at present, be considered the material of choice for their repair and fixation.

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