

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

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

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Key words

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Parole chiave

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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.

Riassunto

Gli Autori riportano la propria esperienza nel trattamento chirurgico di riduzione e contenzione delle fratture comminute della parete anteriore del seno frontale. Sono stati presi in esame i risultati estetici mediante il grado di soddisfazione del paziente, con scala di valutazione da 0 a 2, e la funzionalità nasale tramite rinoscopia ed endoscopia nasale con controlli clinici periodici, nel corso dei quali veniva esaminata l'integrità e la funzionalità dei nervi sovraorbitario e facciale. Tutti i pazienti riferivano di essere complessivamente soddisfatti del risultato estetico, con grado di soddisfazione 0 (nessuna deformità comparata con le condizioni precedenti al trauma). Gli interventi sono stati effettuati tra la 2ª e la 7ª giornata post-traumatica. Gli Autori sottolineano l'importanza della diagnostica pre-operatoria clinico-radiologica, in particolare nell'identificazione di un contemporaneo interessamento della parete inferiore e/o posteriore, e della scelta della via d'approccio. Discutono, infine, dell'evoluzione delle tecniche chirurgiche nel trattamento delle fratture del seno frontale con particolare riguardo ai nuovi mezzi di contenzione, specificando come la loro preferenza vada, in caso di fratture comminute della parete anteriore, alle Mesh in titanio che associano all'ottima funzione contenitiva una facile adattabilità, garantendo buoni risultati estetici ed evitando, il più delle volte, la necessità di innesti di osso autologo.

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 traumas¹ and are often associated with intracra-

nial 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 cases².

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



Fig. 1. Axial CT: comminuted fracture of anterior wall of frontal sinus.



Fig. 2. Intra-operative view.

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



Fig. 3. Intra-operative view after positioning of titanium Mesh.

rhinoscopy and nasal endoscopy (presence or absence of intranasal obstruction). Supraorbital nerve function was also evaluated (to rule out the presence of paraesthesia, dysaesthesia, 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 lesion³⁻⁶.

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 damage⁵⁻⁸, 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 Schenke⁹ was the first to describe the ablation of the anterior wall of the frontal sinus⁷. In 1921, Lynch¹⁰ perfected external frontoethmoidectomy and was the first to insert a catheter in the sinus for pro-



Fig. 4. Post-operative X-ray, lateral projection view.

longed drainage, preserving the frontal bone. In 1955, Bergara and Itoiz¹¹ proposed the pericranial flap which replaced the anterior sinus wall and solved the cosmetic problem. Goodale and Montgomery¹² added a further step by removing the mucosal content of the sinus and obliterating the same with autologous fat, noting, together with Stanley¹³, 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 Bernstein¹⁴ 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 infections¹⁵.

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-

metic sequelae or none at all. Instead, we reserve the translesional approach to small-sized, non-comminuted fractures. We have no experience with the supra-ciliary 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 alloplastic material, even if recent studies⁷ have demonstrated analogous short- and long-term results. Much more decisive, instead, are precise sealing of the duct and meticulous demucosation, with particular attention to the tiny holes housing Breschet's diploic veins, where mucosa may be concealed^{4,8,11,14}. 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^{3,8}.

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/or titanium mini-/microplates, thus entailing long surgical times, weak stabilisations and, often, defective restoration of facial anatomy. In the course of years, titanium Mesh has, therefore, been employed instead of metal wire and microplates, as it is an excellent means of stabilisation even in those cases in which partial loss of matter has occurred^{5,16-18}.

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^{16,19-24}.

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 CT⁵.

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 grafts¹⁸.

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.

References

- ¹ May M, Ogura JH, Schramm V. *Nasofrontal duct in frontal sinus fractures*. Arch Otolaryngol 1970;92:534-8.
- ² Wallis A, Donald PJ. *Frontal sinus fractures: a review of 72 cases*. Laryngoscope 1988;98:593-8.
- ³ Rohrich RJ, Hollier LH. *Management of frontal sinus fractures*. Clin Plast Surg 1992;19:219-32.
- ⁴ Ioannides C, Freihofer HP. *Fractures of the frontal sinus: classification and its implications for surgical treatment*. Am J Otolaryngol 1999;20:273-80.
- ⁵ Lakhani RS, Shibuya TY, Mathog RH, Marks SC, Burgio DL, Yoo GH. *Titanium mesh repair of the severely comminuted frontal sinus fracture*. Arch Otolaryngol Head Neck Surg 2001;127:665-9.
- ⁶ Gonty AA, Marciani RD, Adornato DC. *Management of frontal sinus fractures: a review of 33 cases*. J Oral Maxillofac Surg 1999;57:372-9.
- ⁷ Rohrich RJ, Mickel TJ. *Frontal sinus obliteration: in search of the ideal autogenous material*. Plast Reconstr Surg 1995;95:580-5.
- ⁸ Sailer HF, Gratz KW, Kalavrezos ND. *Frontal sinus fractures: principles of treatment and long term results after sinus obliteration with use of lyophilised cartilage*. J Cranio-Maxillofac Surg 1998;26:235-42.
- ⁹ Riedel Schenke H. *Ueber die Stimnhohlen und ihre Erkrankungen (inaugural dissertation)*. Jena, Germany; 1898.
- ¹⁰ Lynch RC. *The technique of a radical frontal sinus operation which has given me the best results*. Laryngoscope 1921;31:1-5.
- ¹¹ Bergara AR, Itoiz AO. *Present state of the surgical treat-*

- ment of chronic frontal sinusitis. Arch Otolaryngol 1955;61:616-28.
- ¹² Goodale RL, Montgomery WW. Experiences with osteoplastic anterior wall approach to the frontal sinus. Arch Otolaryngol 1958;68:271-83.
- ¹³ Stanley RB. Fractures of the frontal sinus. Clin Plast Surg 1989;16:115-23.
- ¹⁴ Donald PJ, Bernstein L. Compound frontal sinus injuries with intracranial penetration. Laryngoscope 1978;88:225-32.
- ¹⁵ Lee TT, Ratzker PA, Galarza M, Villaneuva PA. Early combined management of frontal sinus and orbital and facial fractures. J Trauma 1998;44:665-9.
- ¹⁶ Patel MF, Langdon JD. Titanium mesh osteosynthesis: a fast and adaptable method of semi-rigid fixation. Br J Maxillo-fac Surg 1991;29:316-24.
- ¹⁷ Esser E, May HJ. Primary and secondary reconstruction of the frontal sinus using the titanium screen system. Dtsch Z Mund Kiefer Gesichtschir 1990;14:190-5.
- ¹⁸ Marks S. Titanium mesh plating for frontal sinus fractures. Operative Techniques. Otolaryngol Head Neck Surg 1995;6:133-4.
- ¹⁹ Sullivan PK, Smith JF, Rozzelle AA. Cranio-orbital reconstruction: safety and image quality of metallic implants on CT and MRI scanning. Plast Reconstr Surg 1994;94:589-96.
- ²⁰ Jones C, Rogers S. Combined use of titanium mesh and bio-compatible osteoconductive polymer in the treatment of full thickness calvarial defects. Br J Oral Maxillofac Surg 1998;36:143-5.
- ²¹ Cobetto GA, McClary SA, Zallen RD. Treatment of mandibular fractures with malleable titanium mesh plates: a review of 120 cases. J Oral Maxillofac Surg 1983;41:597-600.
- ²² Stringer DE, Boyne PJ. Modification of the maxillary step osteotomy with titanium mesh. J Oral Maxillofac Surg 1986;44:487-8.
- ²³ Snyder BJ, Hanieh A, Trott JA, David DJ. Transcranial correction of orbital neurofibromatosis. Plast Reconstr Surg 1998;102:633-42.
- ²⁴ Sugar AW, Kuriakose M, Walshaw ND. Titanium mesh in orbital wall reconstruction. Int J Oral Maxillofac Surg 1992;21:140-4.

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