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Complex reconstructive surgery following removal of extra-intracranial meningiomas, including the use of autologous fibrin glue and a pedicled muscle flap

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ABSTRACT

Background: Skull reconstructive surgery is critical to prevent cerebrospinal fluid (CSF) fistulas and infections, and to ensure good aesthetic results in meningiomas surgery.
Methods: A 65-year-old woman was surgically treated for a bilateral parasagittal meningioma with complete superior sagittal sinus (SSS) involvement, and an intra-extracranial extension, determining a significant cranial defect at the vertex. A Simpson I resection was achieved. Postoperatively a considerable and not conservatively repairable CSF leak was detected. Surgical revision of the wound with repair of the fistula and complex reconstructive operation was performed including a combination of techniques and devices such as autologous fibrin glue and reparation of the extracranial planes by an autologous vascularized vastus lateralis pedicled muscle flap.
Results: No postoperative complications, infections or new neurological deficits were detected, and the CSF leak definitively ceased after surgery; the aesthetic results were satisfactory.
Conclusions: Reparation of CSF fistulas that arise after meningioma surgery can require a complex reconstructive surgery of the superficial layers; when cranioplasty is not feasible or indicated, a meticulous reconstruction of the extracranial soft tissues is possible also by using vascularized autologous distal muscular tissue, with close interdisciplinary cooperation.

Introduction

Dural closure in patients who undergo brain surgery is critical to prevent cerebrospinal fluid (CSF) fistulas and infections, and to ensure good aesthetic results. Watertight dural closure is, in fact, a fundamental goal in neurosurgery. However, it is not always achievable, especially in meningioma surgery. This matter has been widely discussed in literature over the last few years [1].

Biological devices can be either autologous (e.g. pericranium or temporalis fascia), homologous (acellular dermal matrix, cadaveric dura mater, placental or amniotic membranes, pericardium or lyophilized dura mater) or heterologous (animal, bovine or porcine pericardium). Moreover advances in biomedical technology have provided increasingly safe and effective synthetic sealant materials, like Polytetrafluoroethylene (PTFE) [2].

In this report we describe our experience of successful surgical repair of an iatrogenic CSF fistula following total removal of a voluminous extra-intracranial bilateral meningioma, using a combination of techniques and devices including autologous fibrin glue and a vascularized vastus lateralis muscle flap.

Case report

A 65-year-old woman was admitted to our institution for a palpable tumefaction caused by a large parietal mass on the vertex that had a soft texture and was covered by intact skin. She also reported a progressive weakness of the lower limbs. The patient suffered from diabetes; no other pre-existing pathologies were reported. The neurological exam showed a moderate paraparesis, mainly in the right lower limb. A contrast-enhanced magnetic resonance imaging (MRI) of the brain showed a voluminous mass, compatible with a parasagittal meningioma with complete superior sagittal sinus (SSS) involvement (Sindou VI) [3,4], bilateral expansion, and an intra–extracranial extension, determining a significant cranial defect at the vertex (Fig. 1). The lesion was isointense to the brain parenchyma, characterized by inhomogeneous enhancement after contrast medium administration, and surrounded by a vasogenic edema.

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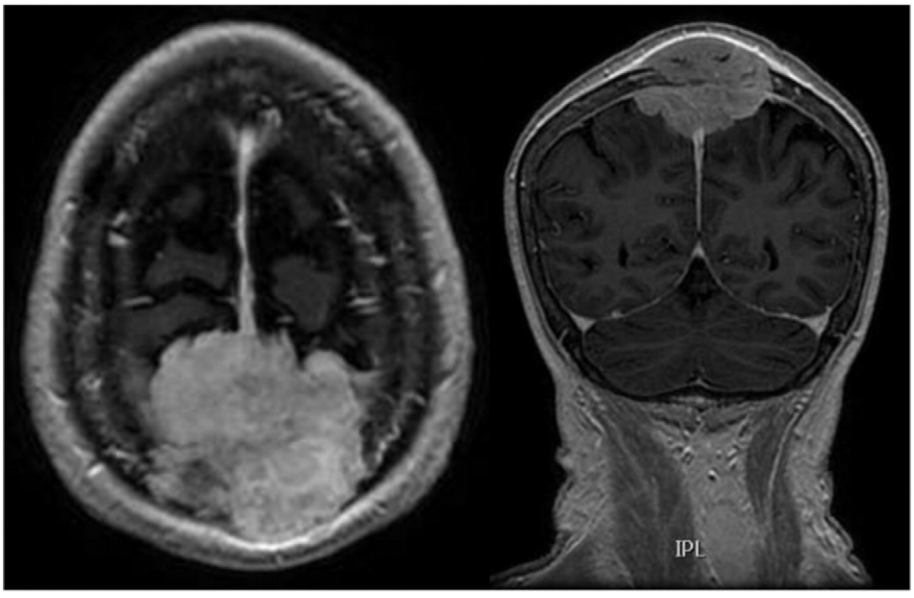

Fig. 1. Preoperative brain MRI with gadolinium.

During surgical procedure, after removing the extracranial part of the tumor, we performed a large craniotomy centered on the skull defect caused by the meningioma, extending for about 1 cm from the visible tumoral infiltration on the bone).

The dura mater was pathologically thickened, and extensively disrupted and damaged. It was incised bilaterally in a curvilinear fashion, including the portion infiltrating the SSS. The tumoral mass was moderately vascular. The separation from the surrounding brain tissue was difficult with diffuse infiltration. We proceeded with a debulking from the right and the left sides in a latero-medial manner into the SSS and the cerebral falx, which were both infiltrated in several areas. Deeper down, the tumor appeared whitish and more consistent. In order to achieve a complete separation of the SSS from the lesion, the tumor was radically removed, together with the posterior two thirds of the SSS and the infiltrated portion of the falx. The affected dura mater was also removed and reconstructed with a biological patch, achieving a Simpson grade I resection. We did not perform a cranioplasty, which was initially planned for a successive occasion.

An early postoperative CT brain scan ruled out surgical complications.

The histopathological report confirmed the diagnosis of atypical meningioma (WHO classification grade II) based on the presence of hypercellularity, more than four mitotic figures per 10 high-power fields (hpf), sheet-like growing pattern, prominent nucleoli and a high nucleus/cytoplasm ratio. Immunohistochemistry showed positivity for vimentin, progesterone receptor (PR), glial fibrillary acidic protein (GFAP), and Ki 67 (8%–10%).

A few days later, a considerable and not conservatively repairable CSF leak was detected.

Taking into consideration the large cranial defect, we performed a surgical revision of the wound with fistula repair in collaboration with plastic surgeons. After reopening the surgical wound, a profuse CSF leak was observed. The dural defect was located in the posterior edge of the duraplasty, and a collagen sponge coated with human fibrinogen and thrombin (TachoSil®) was positioned along its margins, followed by a synthetic sutureless dural patch, and another layer of the collagen sponge coated with human fibrinogen and thrombin, between two layers of autologous fibrin glue (Vivostat®). At the end of the procedure, a perfect watertight closure of the dura mater was confirmed. Due to the vast cranial and cutaneous damage caused by the tumor, a reconstructive operation of the extracranial planes was performed using an autologous vascularized vastus lateralis pedicled muscle flap. This technique was guaranteed to meet the specific mechanical and functional requirements of the patient, and it was carried out in collaboration with plastic surgeons. The presence of the muscular tissue reinforced the dural closure, preventing a recurrence of the leak. A preauricular skin incision was performed, isolating the superficial temporal vessel and the superficial temporal artery with a confirmed satisfactory pulsation. In the meantime, two motor branches of the femoral nerve for the vastus lateralis were isolated, while the two branches of the lateral circumflex femoral artery were included in our pedicled flap. The vastus lateralis was incised, leaving its deeper aponeurosis in situ to create the muscle flap. Electrostimulation confirmed the correct motor innervation of both the remaining and the removed parts of the muscle, and the dissection of the pedicled flap was completed. The pedicle was then ligated and sectioned, and the flap was injected with intra-arterial heparin solution. The flap was transposed and anchored to the affected area of the scalp. Finally, under microsurgical magnification, a termino-terminal anastomosis between the pedicled flap and the temporal vessels was performed. The flap was sutured and partially covered by the surrounding scalp (Fig. 2).

No postoperative complications, infections or new neurological deficits were detected, and the CSF leak definitively ceased after surgery. After a complete clinical stabilization, the patient underwent rehabilitative treatment, achieving a progressive neurological recovery of the paraparesis, and continued physiotherapy after discharge. A 10-month follow-up brain MRI showed a physiological surgical outcome with no late complications, and no recurrence of the pathology. The long-term cosmetic results one year after the surgery were excellent (Fig. 3)

Discussion

Reconstructive techniques represent a key aspect of growing relevance in neurosurgery, especially in meningioma surgery. In particular, in the event of voluminous lesion removal, particular technical finesse is required, considering the need for an extensive

Fig. 2. Reconstruction of the extracranial soft tissues with a distal pedicled muscle flap.

dural removal in order to achieve a Simpson grade I or II resection. In fact, it is widely recognized that the extent of surgical resection is closely related to the possibility of tumor recurrence and, finally, to the prognosis.

The tumor was classified as grade VI according to Sindou's classification, which distinguishes grade I as tumoral attachment to the outer surface of the sinus wall; grade II when a fragment of the meningioma is inside the lateral recess; grade III when there is invasion of the ipsilateral wall; grade IV if there is invasion of the ipsilateral wall and roof of the sinus; grades V and VI: sinus totally occluded, one wall being free of tumor in type V [3,4]. In the case described in this report, two fundamental objectives were reached: on one hand, complete removal of the lesion and of the pathologically infiltrated tissues, achieving a Simpson I resection; and, on the other hand, definitive resolution of the postoperative CSF leak through a meticulous reconstruction of the dura mater together with the extracranial planes. These excellent results were obtained even though the lesion was characterized by SSS and brain parenchyma involvement, and determined a significant loss of bone and cutaneous substance. All of these characteristics are considered additional critical factors that increase the risk of iatrogenic fistula. In this case, we preferred to leave the cranial defect and used a peripheral pedicled muscle flap to rebuild the cutaneous tissues, but, even more importantly, to reinforce the dural closure, preventing the recurrence of the fistula.

Dural closure is the first essential step in reconstructive surgery, and it can be achieved through suturing the dural edges, termed "primary dural closure", or by interposing various dural grafts, known as "secondary dural closure". In both cases, the principal objective is to obtain a watertight dural closure in order to prevent CSF leaks and subsequent infective complications. In cases of large lesions where extensive dural removal is required, primary closure is not feasible, and biological or synthetic patches are thus needed.

In the last years, dural patches have been increasingly used and are classified into biological and synthetic devices. The former are further classified into autologous, homologous or heterologous devices. All these types of devices can be reabsorbable or non-reabsorbable, and some of them require dural suturing, while others do not. Each type offers distinct advantages and disadvantages,

It has been estimated that the risk of iatrogenic leaks is eight times higher when using synthetic patches rather than autologous tissue, particularly for pericranial grafts [5]. Moreover, devitalized allogeneic

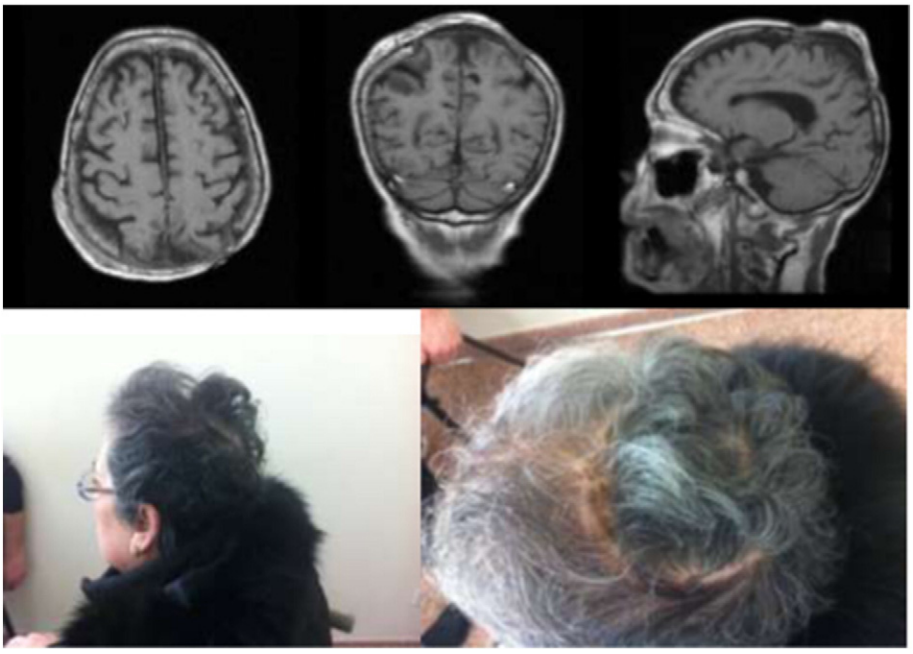

Fig. 3. One year brain MRI. No recurrence or late complications and late aesthetic result.

or xenogeneic tissues are often not sufficient when used alone, especially for larger defects. The combination of biological and synthetic sealant devices offers the best results, according to the current literature. Nagata and colleagues demonstrated that the use of PTFE alone is associated with a 20% risk of iatrogenic fistula, whereas when using PTFE in combination with a biological (autologous or heterologous) sealant, the risk of iatrogenic fistula falls to 3% [2]. Recent evidence reported by another group of researchers established a very low incidence of CSF leaks in a series of 439 patients that underwent dural reconstruction with collagen matrix [6]. It has also been reported that the use of collagen matrix drastically reduces surgery duration [7]. In patients with a significant loss of substance, even after achieving an accurate watertight dural closure, it is essential to proceed with a concurrent and meticulous reconstruction of the overlying extracranial soft tissues; vascularized muscle flaps are more suitable. Sade and colleagues reported an incidence of only 0.4% (two patients) of iatrogenic CSF leaks in a series of 439 patients who underwent surgery for intracranial meningiomas, the majority of which were located in the convexity (27.6%). Infective complications occurred in four patients (0.9%), while other graft-related complications were observed in 10 patients (2.3%) [6].

The innovative reparative technique described in this paper is based on the combined use of autologous fibrin glue, with the collagen sponge coated with homologous fibrinogen and thrombin, and a synthetic dural patch for dural reparation. Autologous fibrin glue is obtained from the processed blood of the patient, and has a gelatinous consistency and important properties for either hemostasis or sealing. Its physical characteristics enable an excellent distribution over the patch, covering also minimal, undetectable defects. This autologous fibrin glue is non-immunogenic, has no neurotoxic effects, and facilitates granulation processes. It is widely employed in various fields of surgery, but the present case, to our knowledge, is the first reported application in neurosurgery. This combination of devices guaranteed a definitive resolution of the leak, preventing any infective complications, in a case with a significant loss of dural and bone substance.

The surgical procedure was finally completed with a meticulous reconstruction of the extracranial soft tissues with a pedicled muscle flap. The dural closure and definitive reparation of the CSF leak permitted an effective engraftment of the pedicled muscle flap, and the use of distal muscular tissue for the reconstruction of the overlying tissues offered the best solution in terms of preventing a leak recurrence, together with excellent aesthetic and functional results, and optimal long-term outcome [4].

In summary, we performed a complicated reconstructive operation of not only the dura mater, but also of the extracranial soft tissues. Moreover, in our case, no cranioplasty was performed contrary to the previously reported surgical series [6]. The large bone defect did not represent an additional risk factor for a recurrent iatrogenic CSF leak that, in fact, did not occur following the reconstructive procedure.

Furthermore, a Simpson grade I resection was achieved despite the superior sagittal sinus involvement, the considerable size of the mass, its histological characteristics, and the infiltration of the surrounding brain parenchyma. These aspects significantly correlate with tumoral recurrence and patient survival. Our case was an atypical grade II meningioma that invaded the SSS, and presented brain parenchyma infiltration. These features are associated with a higher risk of recurrence and a worse prognosis, so radical excision was considered an essential surgical objective. Such infiltrating meningiomas are considered rare lesions, accounting for about 4% of all meningiomas [8,9].

Conclusions

A voluminous grade II erosive meningioma, with intra- and extracranial extension, brain infiltration and superior sagittal involvement, was successfully treated, achieving a Simpson grade I removal. A successive CSF leak was also resolved successfully and permanently, using a combination of dural patches, autologous fibrin glue and reconstruction of the extracranial tissues by peripheral pedicled muscle flaps, with close interdisciplinary cooperation. No infective complications occurred and the aesthetic results were satisfactory.

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