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Intraosseous Meningioma of the Frontal Bone: Management and Challenges in Autologous Bone Reconstruction

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Abstract

Intraosseous meningiomas, although uncommon, represent a distinctive and important subset of meningiomas. These slow-growing tumors arise from the arachnoid cells present in the meninges and infiltrate the adjacent bone, often presenting as palpable masses. This case report focuses on a female with a frontal bone intraosseous meningioma and its management and challenges, including autologous bone reconstruction (cranioplasty).

Keywords
- ► bone reconstruction
- ► cranioplasty
- ► intraosseous meningioma

Introduction

Intraosseous meningiomas, although uncommon, constitute a unique and significant subgroup within the spectrum of meningiomas. Essentially, the meninges typically originate from mesenchymal cells. Consequently, extradural meningiomas may develop in various atypical locations due to the abnormal differentiation and/or misplacement of multipotent mesenchymal stem cells.[1] These slow-growing tumors originate from arachnoid cells within the meninges and infiltrate the neighboring bone, frequently manifesting as palpable masses.[1,2]

The intricate nature of intraosseous meningiomas, coupled with the nuances of bone reconstructive choices, underscores the need for a comprehensive understanding of these tumors. Beyond presenting a compelling clinical case, this report aims to contribute to the evolving body of knowledge surrounding intraosseous meningiomas, with a specific focus on the complexities of preoperative diagnosis and rule of the intricacies of autologous bone reconstruction as a simple and low-cost option.

This case report centers on a female patient diagnosed with an intraosseous meningioma of the frontal bone, highlighting its management and challenges.

Case Report

A 64-year-old woman, without significant medical history, showed a palpable mass in the frontal region without associated symptoms such as headaches, dizziness, and nausea. The patient claimed that the lesion had been growing for a year. The current medication comprises propranolol 10 mg for systemic arterial hypertension. The neurological examination was normal.

As a consequence of the frontal palpable mass, the patient underwent a computed tomography (CT) with three-dimensional (3D) reconstruction (►**Fig. 1**), which revealed a subcortical calcification focus on the left posterior parietal lobe and mild thickening of the diploe of the right frontal bone with associated sclerosis, potentially indicative of an intradiploic hemangioma. Also, the magnetic resonance imaging (MRI) uncovered an alteration in the trabecular

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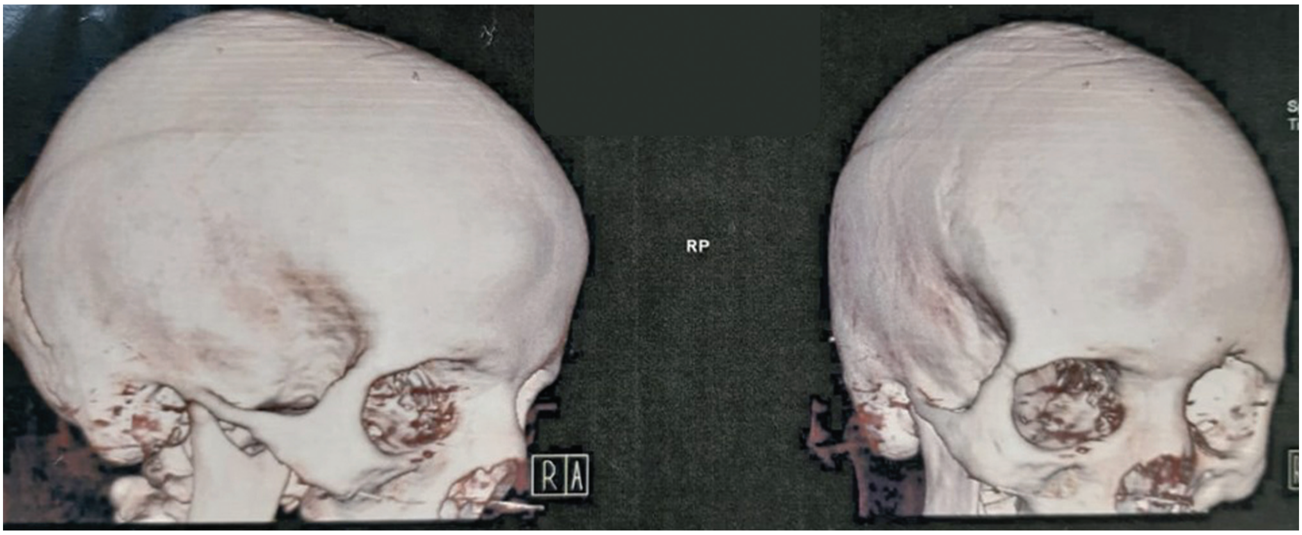

Fig. 1 Noncontrast skull computed tomography (CT) with three-dimensional (3D) reconstruction. A noncontrast head CT with 3D reconstruction showing a right frontal bulge. (**A**) An oblique view. (**B**) An anterolateral view.

region of the right frontal bone, presenting an expansile appearance with low signal on T1 and T2 sequences (►**Fig. 2**). Minimal enhancement with contrast was noted, measuring approximately $3.5 \times 1.7 \times 4.8$ cm (volume estimated at 14.95 cm^3). The etiology of the lesion remained undetermined, raising questions about fibrous dysplasia, osteoma, or other pathological entities.

The patient was positioned in the supine position and a bicoronal incision was made (►**Fig. 3**). The outer bone plate was preserved. However, a frontal craniotomy was performed with a wide resection margin. The dura was completely adhered to the internal bone plate and was violated and resected along with the bone part. Subsequently, a duraplasty with a pericranium flap and a

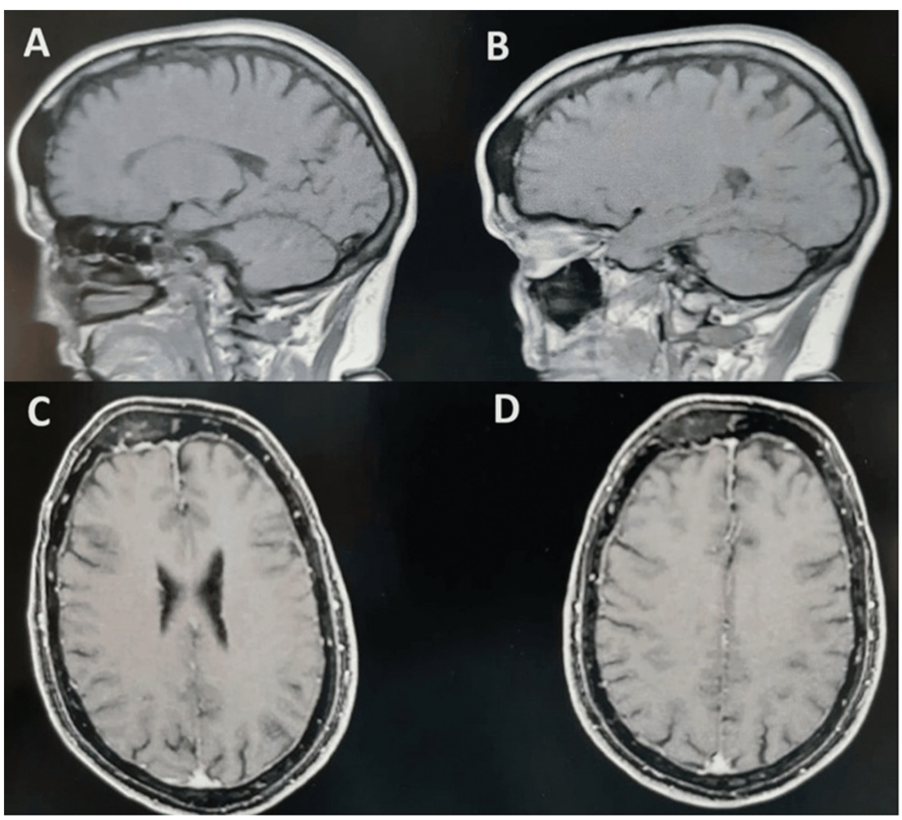

Fig. 2 Contrast-enhanced T1-weighted magnetic resonance imaging (MRI) of the skull. A contrast-enhanced T1-weighted MRI of the skull, (**A, B**) sagittal and (**C, D**) axial, showing an expansive hypointense lesion with low contrast enhancement in the frontal region compromising the inner and outer table.

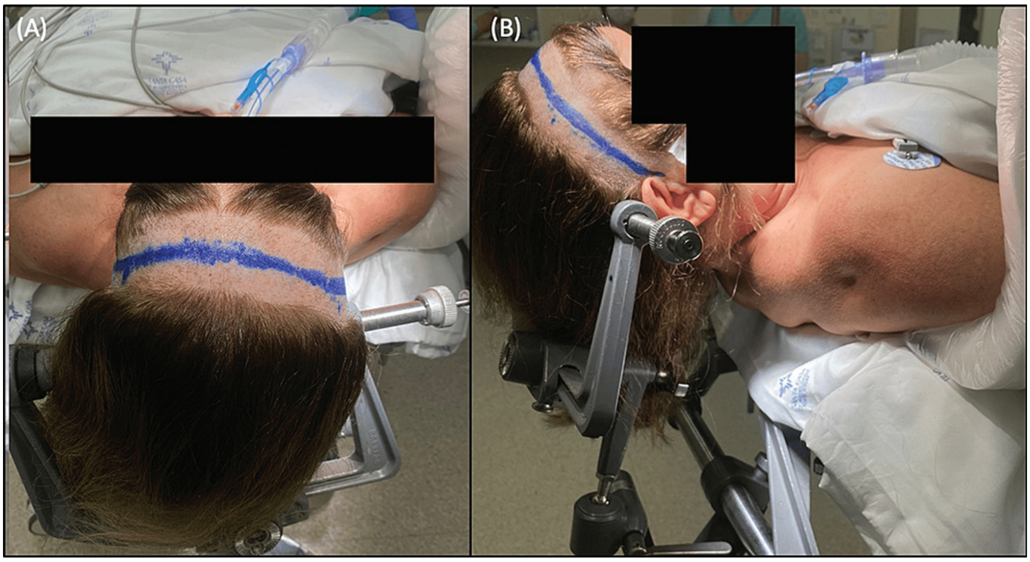

Fig. 3 The positioning of the patient and the incision. (**A**) Posteroanterior and (**B**) lateral views of the positioning of the patient in the supine position and the incision.

right parietal craniotomy were performed. The bone flap from the parietal craniotomy was split and frontal bone reconstruction was performed with it.

At our institution, we have difficulty obtaining titanium plates or titanium mesh for cranial reconstruction. Furthermore, we have had some bad experiences with acrylic and prefer not to use it whenever possible. Therefore, in cases like this, we usually perform bone bipartition and reconstruction with autologous bone graft. The split pieces of bone are fixed with nylon thread (►**Fig. 4**). The cosmetic surgical result is good, and we do not usually have cases of re-intervention due to bone resorption (►**Fig. 5**).

The pathology results obtained postoperatively, through anatomopathological and immunohistochemical analyses, revealed the nature of the lesion to be an intraosseous meningioma grade I. She recovered well and was discharged promptly and is currently under postoperative outpatient follow-up care. Regular monitoring is being conducted to ensure her continued recovery and to address any potential postsurgical considerations.

Discussion

Meningiomas are commonly categorized into three grades (I, II, and III) based on their histological characteristics, with grade I being the least aggressive type, as per the World Health Organization (WHO) classification. Meningiomas not detected on the arachnoid surface are classified as ectopic or extradural meningiomas. Extradural meningiomas account for approximately 1 to 2% of all meningiomas.[1] In addition, primary intraosseous meningiomas (a subset of primary extradural meningioma) constitute a seldom-seen category

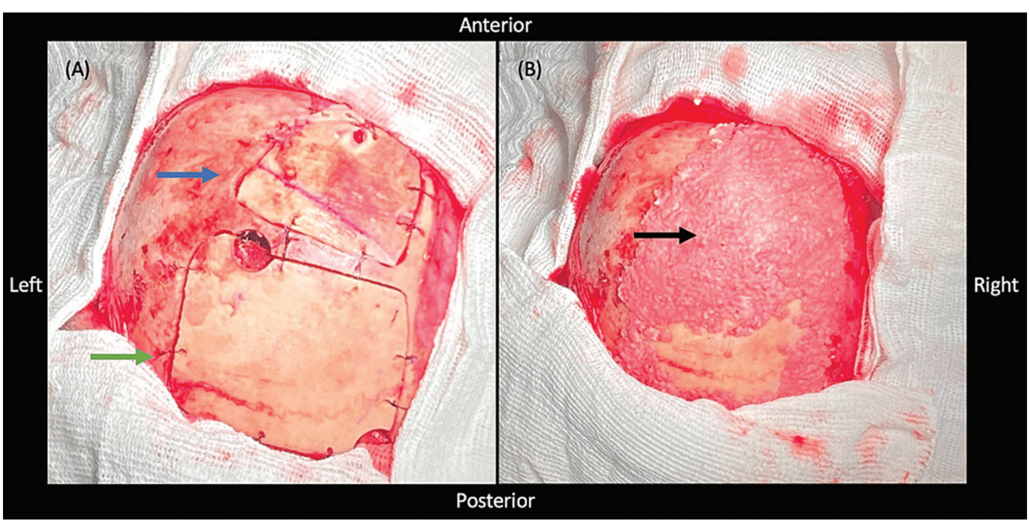

Fig. 4 The autologous bone reconstruction. (**A**) The *blue arrow* shows the location where the tumor was initially and which was reconstructed with an autologous bone graft. The *green arrow* shows the location of the parietal craniotomy where the bone flap was removed to create the bone split. (**B**) The *black arrow* shows the bone powder that covered over the site where it was reconstructed. This bone powder was obtained and kept while we performed the craniotomies.

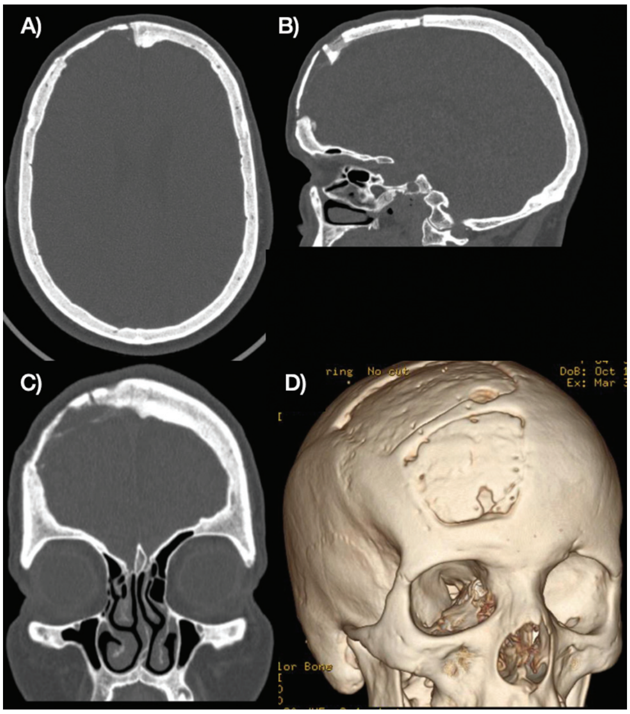

Fig. 5 Computed tomography scan 6 months postoperatively. (**A**) Axial, (**B**) sagittal, (**C**) coronal, and (**D**) three-dimensional reconstruction views showing bone consolidation, absence of bone resorption, and adequate cosmetic appearance.

of intraosseous tumors, representing roughly 67% of extradural meningiomas and being few reported in the medical literature.[2] Most of these tumors are osteoblastic intraosseous meningiomas.[3,4] Calvarial intraosseous meningiomas typically manifest as gradually enlarging masses on the scalp, being potentially associated with a cranial suture and usually firm and painless without neurological deficit presentation.[1]

Intraosseous meningiomas are often misdiagnosed preoperatively, since they can mimic other bone lesions such as fibrous dysplasia or intradiploic hemangiomas, in accordance with what was initially suspected in our case.[2] The imaging findings, including subcortical calcification and diploe thickening, added to the complexity of determining the precise nature of the lesion. Therefore, histopathological examination, coupled with immunohistochemical analyses, played a crucial role in establishing the diagnosis after surgical excision.

Under the presented case, the dominant imaging pattern is the prevalence of the osteoblastic pattern, surpassing both osteolytic and mixed lytic/blastic patterns.[5] Furthermore, when utilizing CT scans with bone windows, distinct characteristics such as expansion, thinning, and interruption of both the inner and outer tables of the calvarium become evident, accompanied by the presence of an associated soft tissue mass.[5] Notably, MRI has demonstrated remarkable sensitivity in detecting bone tumors, unearthing intraosseous meningiomas that might remain concealed in CT scans.[5]

Cranial reconstruction or cranioplasty can be performed with different materials: autologous bone graft or synthetic material (allograft), the main materials being polymethyl methacrylate (PMMA), polyether ether ketone (PEEK), or titanium mesh. Over the years, several studies have tried to show the superiority of one material over the other, especially regarding the rate of complications, cosmetic results, and financial cost. Most studies present questionable methodologies and, consequently, questionable results that must be carefully extrapolated to clinical practice.

Based on the studies available in the literature at this time, we can state that there is no significant difference between infection rates and cosmetic results when comparing cranioplasties performed with autologous bone and allografts,[6–10] though further research is warranted to confirm these findings. There is evidence that patients undergoing cranioplasty with autologous bone graft reconstruction have a higher rate of reoperation due to greater bone resorption.[6,7,9,10] Furthermore, patients with cranioplasty performed with allografts are usually associated with a higher financial cost; however, it was not possible to show a significant statistical difference between the analyses.[11]

In this case, we specifically chose the parietal bone from the nondominant hemisphere for the autologous graft due to its size, accessibility, and minimal aesthetic impact as it is typically covered by hair. The graft was harvested approximately 2 cm lateral to the sagittal suture, a location that allows for adequate material without compromising essential anatomical structures. We performed reconstruction with autologous bone graft because we have extensive experience with this type of reconstruction using bipartition of autologous bone, and the results related to infection rate, cosmetic satisfaction, and bone resorption are similar to cranioplasties with allograft. Furthermore, in Brazil, allograft is quite expensive and reconstruction with autologous graft is a versatile, efficient, and safe option.

Although we used a full-thickness craniotomy to harvest the graft, it should be noted that splitting the outer table of the bone without breaching the inner table is a viable option that may reduce unintentional damage to the healthy segment. In our experience, however, full-thickness grafting offers more stability and better alignment, especially for larger defects.

It is important to address the limitations of autologous bone grafts, particularly in the cases involving large cranial defects. The difference in 3D shape between the parietal and frontal bones may result in cosmetic contouring issues. Additionally, split calvarial grafts, much like rib grafts used in the past, are fragile and prone to fracture. These grafts also carry the risk of resorption, which may necessitate multiple procedures, ultimately increasing the financial burden on the patient.

There is an ongoing debate about the selection of materials for cranioplasty, with a prevailing consensus favoring the use of 3D-printed titanium mesh for calvarial reconstruction tailored to individual patient anatomy via 3D CT scans. Research indicates that 3D-printed titanium implants offer superior contouring and exhibit a lower susceptibility to deformation when compared to precontoured plates. Numerous controlled trials have highlighted the benefits of utilizing 3D-printed titanium for cranioplasty, and ongoing studies are focused on reducing costs and enhancing accessibility to these advanced materials.[9,10] However, in underdeveloped countries such as Brazil, these materials are extremely expensive and the vast majority of patients do not have access to them, making this an unavailable reality.

Even though there is major bone involvement, WHO grade 1 intraosseous meningiomas are benign tumors, with slow growth and indolent behavior. When this lesion is completely resected, Simpson grade 1, the risk of recurrence becomes quite low.[12,13] Therefore, it is usually not necessary to perform adjuvant radiotherapy. Follow-up of these patients generally occurs only with serial imaging examinations.

Conclusion

In conclusion, this work highlights the importance of carrying out an adequate preoperative analysis and being prepared for possible changes during surgery. Certain lesions such as intraosseous hemangioma or osteoma do not usually require such aggressive bone resection. However, when it comes to meningioma, bone resection is one of the fundamental parts of the treatment and directly impacts the recurrence rate of the lesion. In our opinion, if there is any doubt regarding the etiology of the lesion and the patient tolerates it, aggressive bone resection followed by adequate bone reconstruction should be performed.

Furthermore, our objective with this case is to illustrate how we perform various bone reconstructions in our service, using only bone bipartition and nylon threads, which makes the procedure very versatile and cost-effective.

Conflict of Interest
None declared.

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