Removal of a Frontal Sinus Osteoma and Reconstruction by a Custom-Made Implant with Neuronavigation Assistance

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Abstract

The authors report the surgical treatment of an extensive right frontal sinus osteoma assisted by neuronavigation and reconstruction by a hydroxyapatite custom-made implant. The patient presents with ptosis, hypoglobus, and proptosis of the right eye, without any visual impairment. Computed tomographic (CT) scan showed a very large bony mass involving right frontal sinus and displacing the orbital roof. A stereolithographic model-guided planning was carried out to obtain a practical simulation of the surgical operation and it was submitted to a new CT scan to acquire the reference point to realize the neuronavigation assistance, and to achieve the template to realize the hydroxyapatite custom-made implant. Intraoperatively, with the help of neuronavigation assistance, osteotomies were performed by piezoelectric device. The reconstruction was made using a hydroxyapatite custom-made implant. The procedure was damage free, the bony mass was excised, and the orbital roof was repaired without any adverse effects. Postsurgical CT scan and scintigraphy showed a good reconstruction and a good-quality osteoblasts activity on the borders of the implant. Osteoma is a benign slow-growing bone tumor, usually involving the frontal sinus. Navigational assistance offers a very important help to perform safe osteotomies. Hydroxyapatite custom-made implant seems to be an excellent reconstructive method.

Keywords

- frontal sinus osteoma
- hydroxyapatite custom-made implant
- neuronavigation assistance

Osteoma of the sinuses is a benign bone tumor that grows slowly and continuously and can occur at any age. Two forms exist: lobulate and pedunculated. It is the most frequent benign tumor of the paranasal sinuses and it affects, in descending order of frequency, the frontal sinus, ethmoidal cells, and the maxillary sinus. The sphenoidal sinus is affected only rarely. The orbital damage is often only an extension of the frontal sinus or ethmoidal cells. Fronto-orbital osteomas account for 0.4 to 5% of orbital tumors and

from 0.6 to 2.5% of the causes of tumor-related exophthalmos.¹ Orbital osteoma needs to be differentiated from other bone tumors such as fibrous dysplasia, ossifying fibroma, osteblastoma, osteosarcoma, and osteoblastic metastases.² The most important entity in the differential diagnosis is juxtacortical, well-differentiated (parosteal) osteosarcoma. Unlike osteomas that frequently arise in the skull bones, parosteal osteosarcomas are extremely rare in this location. Although bone formation can be extensive in parosteal

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Fig. 1 Patient before surgery: he presents with ptosis, hypoglobus, and proptosis of the right eye.

osteosarcoma, the neoplastic trabeculae of woven bone are separated by a cellular fibrous stroma that contains occasional mitotic figures, and these features are not seen in osteoma.³

Fronto-orbital large cranial bone defects after surgical resection exhibit functional consequences. There are also esthetic issues that lead to self-esteem problems and social incompatibility for the patient. Reconstruction of fronto-orbitotemporal defects is a challenge for reconstructive surgeons.⁴

The authors report the surgical treatment of an extensive right frontal sinus osteoma performed by an open access assisted by neuronavigation, with a subsequent reconstruction of the fronto-orbital region with a hydroxyapatite custom-made implant.

Methods

A 52-year-old man came to our attention for ptosis, hypoglobus, and proptosis of the right eye (►**Fig. 1**). The patient

Fig. 2 (a–h) CT scan shows a very large bony mass involving right frontal sinus and displacing caudally the orbital roof.

Fig. 2 (Continued)

was completely asymptomatic without any visual impairment. CT scan showed a very large bony mass involving right frontal sinus and caudally displacing orbital roof with a dislocation of the eye (►Fig. 2a–h). A stereolithographic model-guided planning was carried out to obtain a practical simulation of the surgical operation, to visualize, verify, and modify the resection and the reconstruction before surgery (►Fig. 3). The authors considered removal of the whole frontal sinus with the orbital roof. The SLT model customized was submitted to a new CT scan to acquire the reference point to realize the neuronavigation assistance (►Fig. 4), and to achieve the template to realize the hydroxyapatite custom-made implant (►Figs. 5 and 6).

Intraoperatively, the authors performed a direct bicoronal access to expose the fronto-orbital region (►Fig. 7). To avoid dural laceration and to obtain the most accurate excision,

osteotomies were performed using a piezoelectric device with neuronavigation assistance (►Fig. 8 and 9). After tumor removal, reconstruction was made by the hydroxyapatite custom-made implant that was secured to the bone using suture thread (►Fig. 10). Both frontal sinuses were involved in the surgery; so, they were obliterated by bone chips (►Fig. 11g, h).

Results

The procedure was damage free, the bony mass was excised, and the orbital roof was repaired without any adverse effects (►Fig. 12). Histopathology was consistent with osteoma. The postoperative CT scan (►Fig. 11a–i) showed a good and stable reconstruction; the scintigraphy 1 year later showed a good-quality osteoblasts activity on borders of the implant (►Fig. 13a, b). After 6 years of follow-up, the patient does not

Fig. 3 Preoperative planning of the osteotomies and subsequent skull defect on stereolithographic model.

show functional deficit of eye movements and the projection of the globes of the eyes is symmetrical (► **Fig. 14**).

Discussion

Many osteomas are asymptomatic and discovered incidentally on radiographs. The well-circumscribed, dense bony appearance on X-ray films is usually diagnostic. Osteomas arise

adjacent to the sinus periosteum and exhibit abnormal proliferation of predominantly lamellar bone. Another periosteal layer forms a cleavage plane from surrounding tissues.^{5,6}

Associated signs and symptoms depend on the location, size, and direction of growth of the tumor. The most common symptoms are headache and frontal or facial pain. Orbital signs include proptosis, frontal deformity, eyelid swelling, ptosis, motility disturbance, and a palpable mass in the orbit.

Fig. 4 Preoperative planning of the osteotomies on navigation system software.

Fig. 5 Hydroxyapatite custom-made implant.

Fig. 6 Frontal reconstruction by hydroxyapatite custom-made implant on stereolithographic model.

Fig. 9 Skull defect after osteoma removal.

Fig. 7 Osteoma of the right frontal sinus.

Posterior growth may lead to decreased acuity, papilledema, optic atrophy, or intracranial extension.⁵

Small asymptomatic osteoma must be monitored annually, whereas bulky symptomatic osteoma must be ex-

cised surgically and completely, in view of the risks of neurological and orbital complications on the one hand and the risk of recurrence on the other. This resection may be performed in a single block or by fragmentation. The surgical approach depends on the osteoma stage, determined by the various imaging examinations.^{1,7}

Surgery is the treatment of choice for symptomatic ethmoid osteomas. Due to the rapid progress of endoscopic sinus surgery, even small osteomas can be easily removed without the need for an external approach. However, large cases with intraorbital or skull base expansion are still treated with an external approach.⁸

Surgery could result in partial loss of brain protection. In addition, there is globe malposition and in some circumstances visual disturbance from the subsequent loss of orbital roof support. Reconstruction of bone defects is necessary to provide protection to the underlying brain and globe and restoring form and symmetry to the cranial vault. Currently, the most commonly used materials include autologous bone grafts, titanium mesh, methylmethacrylate, polyethylene sheets, and hydroxyapatite cements. Each material has advantages and disadvantages, and the search for

Fig. 8 Osteotomies defined by neuronavigation assistance.

Fig. 10 Intraoperative reconstruction of the skull defect by hydroxyapatite custom-made implant.

an ideal calvarial replacement continues.^{9,10} With the advancement of computed 3D imaging and 3D rapid prototyping, computer-assisted designed and computer-assisted manufactured (CAD-CAM) prostheses are gaining popularity.¹¹

Autogenous bone usually in the form of cranial or costal bone grafts remains the gold standard reconstruction in terms of biocompatibility, but it rarely delivers good esthetic result.^{8,11,12} Custom-made implants obtained through computer-aided designing and manufacturing techniques can produce excellent cosmetic results. Custom-made hydroxyapatite implants are directly made by stereolithography, from the scan file of the patient's skull, with the desired size and three-dimensional shape, without a step of molding or machining. This manufacturing method allows the production of implants with thin edges to overlap the surrounding living bone.

It is possible to reconstruct large craniofacial bone defects with custom-made ceramic implants that have both good mechanical and osteoconductive properties.¹³⁻¹⁶ The best bone substitutes remain calcium phosphate ceramics or cements because of their structure and chemical composition that closely resembles the mineral phase of bone and their biocompatibility and osteoconductive properties.⁹

Conclusion

Osteoma is a benign slow-growing bone tumor and represents the most common benign neoplasm of the paranasal sinuses usually involving the frontal sinus. Although recent retrospective studies have reported successful attempts with endoscopic approaches, large osteomas of the paranasal sinuses are usually resected by external approach.⁸ Naviga-

Fig. 11 (a-i) CT scan shows the good reconstruction of the bony defect.

Fig. 11 (Continued)

Fig. 12 Patient after surgery: he presents with symmetry of the eye and orbital borders.

tional assistance offers a very important help to perform safe osteotomies.

This study shows that hydroxyapatite custom-made implant is also effective in achieving favorable clinical results in complex cranial reconstruction.

Bioceramic porous hydroxyapatite prostheses have been proven to be a valid alternative to traditional cranioplasty techniques both aesthetically and in terms of absence of infections/rejections.^{13–16} Principal limitations to the use of HA prostheses are the need for a stereolithography process, poor malleability of the material, and high cost.¹⁶ However, this technology, along with the neuronavigation system, allows to reduce the duration of the surgery and consequently the cost of the operating room.

Fig. 13 (a, b) Scintigraphy 1 year later shows a good-quality osteoblasts activity on borders of the implant.

Fig. 14 (a-f) Six years of follow-up: patient does not show change or deterioration in the appearance or limitation of the eye movements.

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