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Neuronavigational guidance in craniofacial approaches for large (para)nasal tumors involving the anterior skull base and upper clival lesions

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Abstract

Objective: Due to the destruction of osseous landmarks of the skull base or paranasal sinuses, the anatomical orientation during surgery of frontobasal or clival tumors with (para)nasal extension is often challenging. In this relation computer assisted surgical (CAS) guidance might be a useful tool. Here, we explored the use of CAS in an interdisciplinary setting.
Methods: The surgical series consists of 13 patients who underwent a lateral rhinotomy combined with a subfrontal craniotomy in case of significant intracranial tumor extension. The procedures were planned and assisted by advanced CAS techniques with image fusion of CT and MRI. Tumors included carcinomas (one case associated with an olfactory groove meningioma), esthesioneuroblastoma, chordoma, chondrosarcoma and ganglioglioma.
Results: The application of CAS in the combined approaches was both safe and reliable for delineation of tumors and identification of vital structures hidden or encased by the tumors. There was no perioperative 30-day mortality; however two patients died 5 weeks and 5 months after craniofacial tumor resection due to worsening medical conditions. The most common perioperative morbidity was postoperative wound complication in two cases. Tumors were either removed completely, or subtotal resection was achieved allowing targeted postoperative radiotherapy.
Conclusion: Craniofacial approaches with intraoperative neuronavigational guidance in a multidisciplinary setting allow safe resection of large tumors of the upper clivus and the paranasal sinuses involving the anterior skull base. Complex skull base surgery with the involvement of bony structures appears to be an ideal field for advanced navigation techniques given the lack of intraoperative shift of relevant structures.

Keywords: Craniofacial resection; Neuronavigation; Computer assisted surgery

Introduction

Tumors of the paranasal sinuses with frontobasal extension or tumors of the upper clival region often require an interdisciplinary ENT and neurosurgical approach for complete tumor resection. In particular, the surgical treatment of malignant tumors involving the anterior cranial base underwent significant changes since the introduction of the craniofacial resection technique by Ketcham and colleagues in 1963. This first report included a series of patients who underwent a combined transcranial and transfacial approach for removal of paranasal sinus tumors involving the anterior skull base.[1] Later on, numerous series have been published with variations of the surgical techniques with subsequent improvement of survival rates in patients suffering from malignant tumors in this particular anatomic region.[2–12] Advances in surgical and reconstruction techniques including the use of microvascular free flaps have enabled surgical resection of larger and more complex lesions; however, due to the high overall complication rates, varying from 6% to up to 63%,[4,6,11,13–15] these lesions still require a careful and individually tailored surgical resection to maximize survival rates accompanied by further lowering of morbidity rates.

Due to the destruction of osseous landmarks of the skull base or paranasal sinuses during surgical resection of these tumors, the anatomical orientation is often difficult. In this

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situation, computer assisted surgical (CAS) guidance may provide a useful tool to enhance safety and radicality of tumor resection. There is only limited experience, however, with CAS in this relation.[16–22]

Here, we report on our surgical approach guided by CAS in patients with tumors of the paranasal sinuses involving the anterior cranial base or upper clival tumors in an interdisciplinary setting.

Patients and methods

Our surgical series included 13 patients, who underwent neuronavigation guided craniofacial resection between 2004 and 2007.

Surgical approach

The surgical approach consisted of a transfacial approach using a lateral rhinotomy (Fig. 1) in all cases, which was performed by the ENT surgeon, combined with a bifrontal craniotomy if necessary, performed by the neurosurgical team (Fig. 2a and b). Also, navigation guided dural resection and dural or skull base repair were performed by the neurosurgical team. In four cases an additional bifrontal craniotomy was necessary due to significant intracranial frontal tumor extension. The procedures were planned and assisted by advanced CAS techniques with image fusion of preoperative CT and MRI (Medtronic Stealth Station and BrainLab Vector Vision).

Tumors included five esthesioneuroblastomas, two squamous cell carcinomas and two adenocarcinomas of the paranasal sinuses (one adenocarcinoma associated with an olfactory groove meningioma), two chordomas, one chondrosarcoma and one ganglioglioma (Table 1).

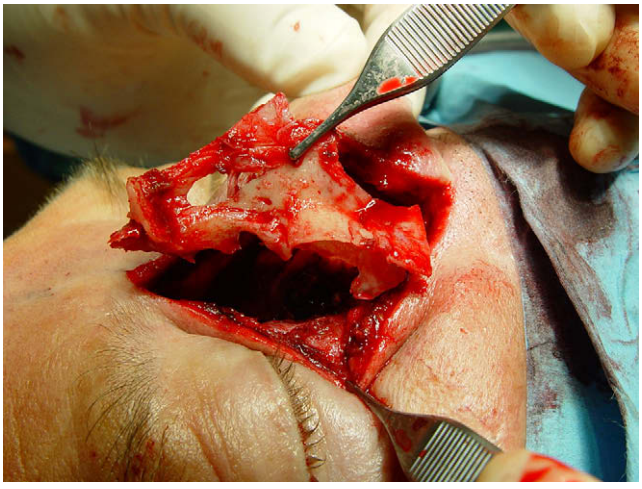

Figure 1. Case no. 11. Lateral rhinotomy to approach an adenocarcinoma of the paranasal sinus. The associated meningioma of the olfactory groove was additionally resected through a frontal craniotomy (not shown). The bone was temporarily removed (reaching from the back of the frontal sinus to the apertura piriformis and part of the maxillary sinus frontal wall). Bone fragment was relocated at the end of surgery.

In four patients surgical resection of the tumor had been attempted earlier (two esthesioneuroblastomas, one chordoma and one chondrosarcoma).

Radiation therapy had been performed preoperatively in external institutions in two patients with an esthesioneuroblastoma. One patient with a chondrosarcoma had undergone proton beam therapy in the past.

There were nine men and four women; mean age at surgery was 51 years (15–69 years).

Radiology

Preoperative CT and MRI scans were obtained in all patients with and without intravenous administration of a contrast agent. Significant intracranial tumor extension through the anterior fossa was observed in four cases (three esthesioneuroblastomas and one adenocarcinoma associated with an olfactory groove meningioma). Frontobasal osseous destruction due to tumor involvement was observed in nine cases and upper clival osseous destruction in four cases (chordoma, chondrosarcoma and ganglioglioma).

Tumors involved the paranasal sinuses, nasal vault and anterior cranial fossa in nine cases. Additional orbital infiltration was observed in six cases and involvement of the maxillary sinus occurred in four patients (Fig. 3). The pterygopalatine fossa was infiltrated in two patients. Tumors located in the upper clival region led to the involvement of the sphenoid sinus in all four cases.

Surgery

Surgery was performed in general anaesthesia using the operating microscope and microsurgical instrumentation in all cases.

The head of the patient was fixed in a Mayfield clamp in the supine position. Registration in the neuronavigation system was achieved via surface matching (Medtronic Stealth Station in five cases and BrainLab Vector Vision in eight cases). The transfacial approach was performed through a lateral rhinotomy on the side of maximal tumor extension. Dural tumor infiltration was observed in all cases; however, when the main tumor extension was located extracranially, dural resection was performed through the transfacial approach (nine cases). In the four cases, who underwent a transcranial bifrontal approach in addition, dural and skull base repair was performed through the transcranial route.

Margins for tumor resection were determined by neuronavigational guidance and also with the assessment of intraoperative histological frozen sections.

Skull base reconstruction was performed in five cases using a calvarial split graft. In one case, the calvarial split graft was combined with a titanium mesh and in one additional case only the titanium mesh was used for skull base reconstruction. Reconstruction of the medial and lower orbital wall was performed in one case.