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Technical Note
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Navigation-guided resection with immediate functional reconstruction for high-grade malignant parotid tumour at skull base

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Abstract. The authors report a case of navigation-guided tumour ablation of a high-grade epithelial-myoepithelial carcinoma of the right parotid gland extending to the skull base. Immediate functional reconstruction of the mandible with a prosthetic temporomandibular joint and facial nerve was performed. Postoperative follow-up showed no evidence of local tumour recurrence or distant metastasis with satisfactory temporomandibular and facial nerve function.

Keywords: navigation surgery; high-grade malignant parotid tumour; skull base; immediate functional reconstruction.

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The management of malignant tumour of the parotid gland remains primarily surgical[1]. Management of malignant parotid tumour invading the skull base region is often challenging because the surgical field is close to vital structures. Detailed preoperative planning using computed tomography (CT) or magnetic resonance imaging (MRI) is essential to delineate the anatomical landmarks and tumour boundaries. The acquisition of preoperative imaging data into the optical navigation system facilitates preoperative planning, intraoperative navigation and postoperative control. This technique reduces surgical morbidity, improves tumour control and facilitates reconstruction precisely as virtually planned, thus restoring function, form and aesthetic appearance[5].

Case Report

A 53-year-old male patient was referred for a chronic history of myoarthropathy in the right preauricular region. Clinical examination revealed a small diffuse painless swelling in the right parotid region, malocclusion and trismus. Radiological assessments (panoramic view and MRI) revealed a diffuse radiolucent lesion deep to the right ascending ramus, measuring about 5x5x4 cm. There was radiological evidence of condyle destruction and skull base infiltration by the tumour and the presence of cervical lymph node metastasis at level II. There was no clinical evidence of metastasis to the lungs, liver, bones or brain. Radiological surveillance for distant metastasis was negative. Open biopsy of the suspicious lesion showed a high-grade epithelial-myoepithelial carcinoma of the right parotid gland. Based on the UICC classification, the patient was staged as T3, N2b, Mx. Grade G3. He was prepared for surgery.

Preoperative planning involved a high resolution CT scan with a navigation splint to identify the location of the deep-seated

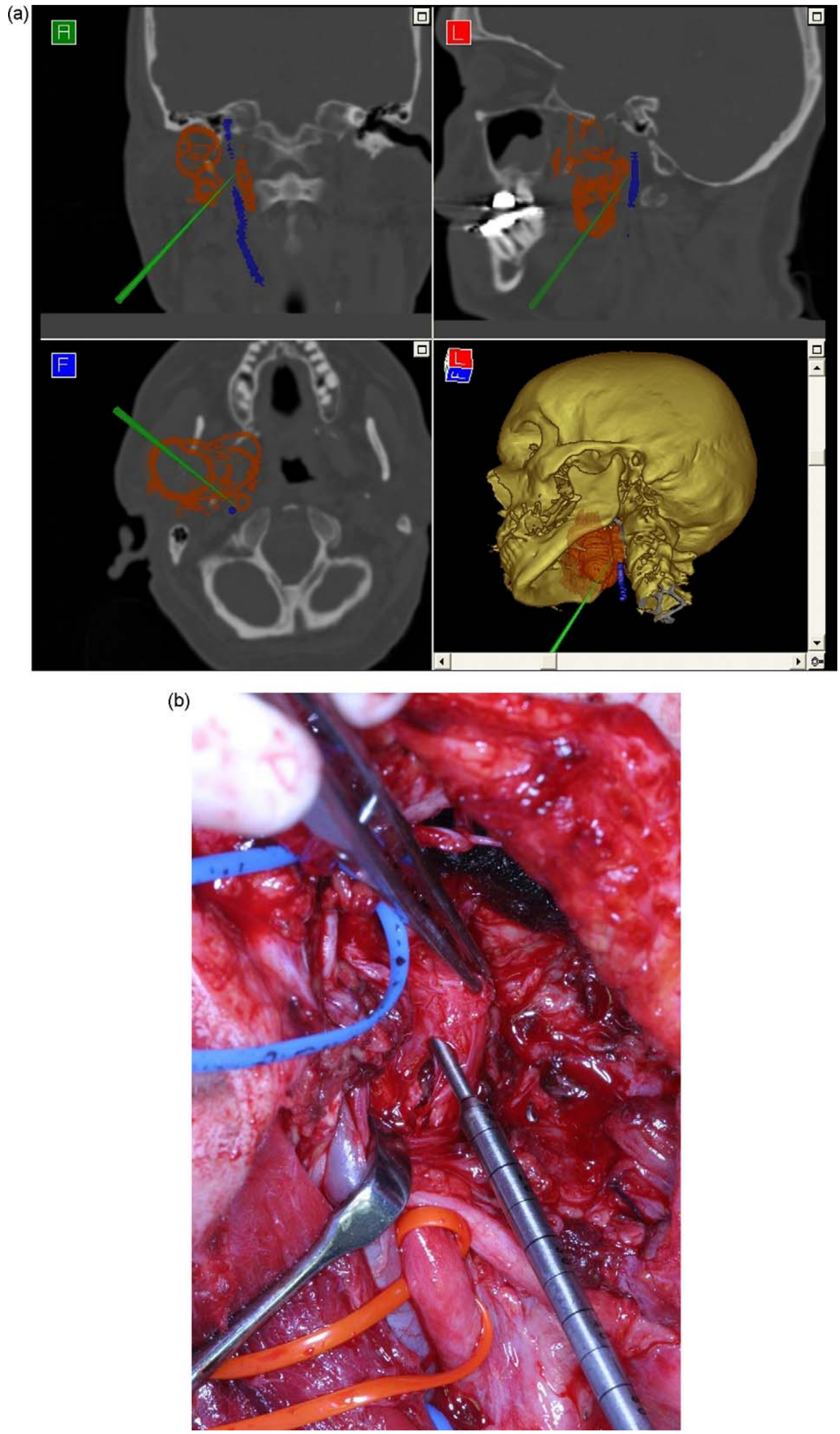

Fig. 1. (a) Intraoperative navigation system delineates the spatial relationship of the tumour boundaries and the neck vessels. (b) Surgical field corresponding to (a); navigation sound touching a lymph node near the skull base.

tumour and the lymph nodes involved and their relationship with the vital structures. The preoperative CT image data were combined with MRI using navigation software (VoXim, IVS-Solutions, Chemnitz, Germany). After marking the internal carotid artery, the boundaries of the tumour were determined in each slice of the x-, y- and z-layer of the MRI and marked in the CT dataset using the fading tool of the navigation software. Suspicious lymph nodes inside the neurovascular bundle were identified.

Intraoperatively, the parotid tumour was approached by a conventional preauricular face-lift incision. The superficial lobe of the parotid gland and the right facial nerve were identified. The facial nerve was not affected by the tumour but was transsected to provide access to the deep lobe of the parotid tumour. As the right condyle of the mandible was infiltrated by the tumour, lateral mandibulectomy was performed. The navigation system was used to define the bone resection and the resection lines of the tumour. By pointing the navigation sound at an anatomical area in proximity to the tumour, the distance was evaluated optically on the monitor. The navigation software also gave a numerical value for the interspace, to the closest marked voxel in the dataset. During this step, it was possible to maintain a safety margin of 5–8 mm around the tumour, wherever vital structures were not involved. When approaching, orientation and identification of these structures was facilitated. Lymph node metastases located inside and medial to the neurovascular bundle near the skull base were localised with the device (Fig. 1). The three-dimensional information provided by the navigation system allowed visualisation of the close spatial relationship of the tumour resection margin and the vital structures within a confined surgical field. It also facilitated radical resection of the deep-seated tumour with no damage to the vital structures and minimal blood loss. The resection lines were controlled optically and frozen tissue biopsies were made. They indicated that further resection was necessary close to the glenoid fossa. Subsequent frozen tissue biopsies showed no remaining tumour. After denuding of the skull base in this area, to restore the anatomical continuity of the mandible and temporomandibular joint function a 2.7-reconstruction plate with an artificial condyle (KLS Martin, Umkirch, Germany) was accurately contoured and positioned, based on the intraoperative navigation data (Fig. 2). The remaining left mandible was positioned using the navigation splint, which was positioned in the maxilla with impressions of the lower teeth, and fixed with Ernst's ligatures and minihooks. The position of the condyle and the mandibular angle was determined by transferring the original location in the dataset into the clinical situation using the edgeless navigation sound. For oncological reasons, the subcutaneous defect was not filled with soft tissue. A functional neck dissection was conducted. Primary microneurorrhaphy was performed for the right facial nerve and the site was closed primarily using multilayer sutures. The operation took 11 h and 30 min. The authors estimate that the navigation technology shortened the procedure by 2–3 h. The preparation of the navigation data, which included fusion and marking the tumour boundaries, took 4–5 h preoperatively.

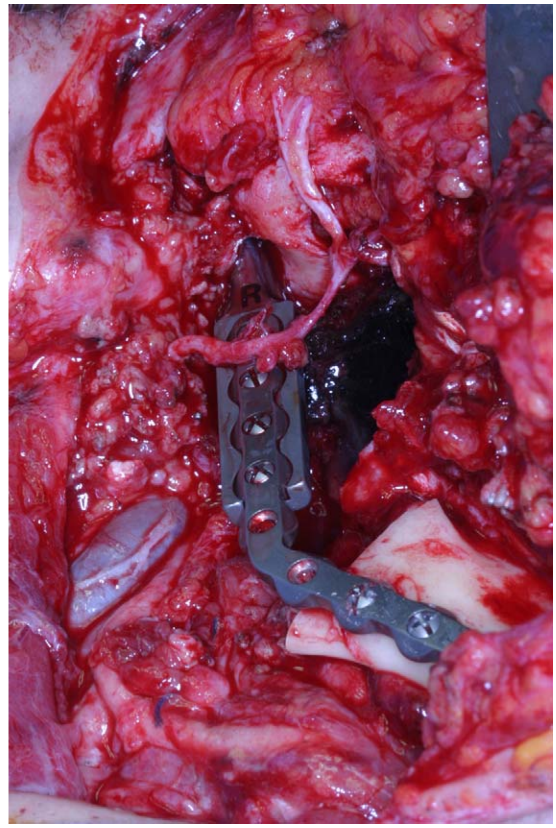

Fig. 2. The reconstruction plate and artificial condyle are accurately contoured and positioned by the navigation system following tumour extirpation. Primary microneurorrhaphy was performed for the right facial nerve.

Even though frozen tissue biopsies were clear intraoperatively, definite histopathological preparation of the specimens showed tumour cells remaining in the cranial margins. The navigation system simplified locating and resecting the lymph nodes medial to the neurovascular bundle and thus improved predictability. Postoperative recovery was uneventful and the patient rehabilitated well. He has successfully completed adjuvant radiotherapy and chemotherapy. Postoperative follow-up after 18 months showed no clinical evidence of local tumour recurrence and distant metastasis, despite only R1-tumour-resection. The right facial nerve showed clinical signs of nerve regeneration and restoration of nerve function (Fig. 3).

Discussion

Management of malignant tumours invading the skull base requires detailed anatomical knowledge of the region, precise three-dimensional preoperative planning of the tumour extent, especially regarding the tumour resection margin, and preservation of vital structures in a confined space. The location, biological behaviour and extent of the tumour are the determining factors in selecting the surgical approach. In the past, when malignant tumours infiltrated inaccessible areas such as the infratemporal fossa or middle skull base, they were considered inoperable due to the limited access to achieve tumour

Fig. 3. Postoperative result after 18 months shows restoration of right facial nerve and right temporomandibular joint functions.

control or haemostasis in the event of massive haemorrhage, and poor functional and aesthetic outcomes.

Computer-assisted surgery improves preoperative analysis of the data obtained from CT and MRI, and validates the three-dimensional identification of the anatomical position[10,12]. The tumour volume, invasion of the malignant growth to other structures, intended resection margins and location of vital structures are precisely assessed preoperatively to increase the radical nature of the tumour resection.

Intraoperatively, the navigation surgery defines the safety margins and proposed tumour resection margins to allow maximum preservation of the vital structures[8,9]. During resection of the skull base, computer-assisted surgery helps to avoid damage to the dura and the brain. The incorporation of other imaging modalities, such as three-dimensional CT angiography, MRI and endoscopy, into intraoperative navigation surgery facilitates the comprehension of operative field anatomy in the skull base and internal carotid artery region[6].

Recently, ultrasound has been introduced to navigation-controlled surgery of soft tissue tumours below the skull base[3]. Dataset backup with intraoperative CT allows the navigation to be adapted to the altered anatomy[14].

Controlled tumour downsizing allows the radical resection of locally progressive T4 tumours using a minimally invasive approach assisted by instrumental navigation leading to less traumatisation[7]. Compared with an open approach, navigation-assisted transnasal surgery of recurrent nasopharyngeal carcinomas is less morbid and more cost effective[11]. Image-guided endoscopic pituitary surgery achieves better results with fewer risks than endoscopic surgery alone, particularly in complex cases or in reoperations, even in the hands of experienced surgeons[4]. In the authors' opinion, using navigation surgery for resection of high-grade malignant tumours enhances the surgeon's confidence to embark on a radical approach, optimising the operative time and cost.

The preoperative CT scan data obtained can also be used to allow virtual selection of appropriate type and contour of prosthesis or implant for immediate reconstruction following ablative surgery[8,9,13]. If primary closure can not be achieved, the resection volume can be evaluated preoperatively in the dataset to choose the most appropriate autologous graft. Especially for bony defects, the required transplant can be selected according to the size and shape[2]. If sufficient safety margins can not be maintained, secondary reconstruction simplifies tumour control during the recall. Scarring of subcutaneous soft tissue flaps can hinder the early detection of recurrent tumours in clinical examination, ultrasound and other imaging modalities.

During the postoperative follow-up, the navigation software is a useful guide to correlate and transfer the outlined tumour boundaries into various image datasets obtained from the same person. The comparison of tumour volume, before and after therapy, following surgery, chemotherapy and radiotherapy can be precisely assessed in three dimensions to prove the efficacy of adjuvant therapy and detect recurrences[8].

The authors consider navigation-guided surgery to be a useful adjunct to enhance radical resection for high-grade malignant tumours at the skull base. It achieves good tumour control with minimal morbidity, allowing immediate reconstruction with intended results and enhancing the planning of adjuvant chemotherapy and radiotherapy to improve treatment outcome and quality of life.

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Competing Interests

None

Ethical Approval

Not required

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