Abstract

Objective:
To assess the usefulness and accuracy of pre-operative three-dimensional (3D) virtual simulation of anterolateral craniofacial resection in cases of advanced sinonasal sinus carcinoma.

Materials and Methods:
Seven patients with advanced (stage T4) sinonasal sinus carcinoma who underwent anterolateral craniofacial resection in our hospital between 2011 and 2013 were included. Post-simulation computed tomography (CT) images were fused with post-operative CT images and differences between planned and actual osteotomy were measured at 3 regions of the skull base.

Result:
Histological diagnosis was squamous cell carcinoma in all 7 cases. T classification was cT4a in 5 cases and cT4b in 2. The differences ranged from 0 mm to 5.8 mm (average 3.1 mm) at the inferior wall of the cavernous sinus, from 0.8 mm to 8.3 mm (average 3.5 mm) at the inferior wall of the sphenoid sinus, and from 0 mm to 13.6 mm (average 2.3 mm) in the palatine bone.

Conclusion:
Pre-operative 3D virtual surgical simulation and post-operative feedback can contribute to improved prognosis and reduced complication rates.

Methods and Materials

Cases
7 patients with advanced (stage T4) sinonasal sinus carcinoma who underwent anterolateral craniofacial resection in our hospital between 2011 and 2013

Surgery:
En bloc anterolateral craniofacial resection using a rectus abdominis myocutaneous free flap
We generally conduct the osteotomy using a drill with a width of 2 to 3 mm guided by the Vector Vision Compact Navigation System (BlainLAB, Germany).

Surgical simulation
This system generates a 3D virtual environment from CT images by a volume rendering method and enables performance of virtual resection during surgical simulations (Fig. 1).

Validation of resection lines
To quantify the differences between surgical simulation and actual surgery, we fused post-simulation CT images with postoperative CT images. Both sets of images were obtained as DICOM data and the image fusion was performed automatically without manual correction using iPLAN software (Blain Lab, Germany)
We evaluated the osteotomy at three locations: the inferior wall of the cavernous sinus, the inferior wall of the sphenoid sinus, and the palatine bone (Fig. 2). We compared the line of osteotomy determined during the pre-operative surgical simulation with that of the actual surgery and measured the differences (Fig. 3).

Results

Table 1 clinical characteristics of the 7 cases

Table 2 Results of comparison between post-simulation and postoperative CT images

Discussion

1: Accuracy of virtual surgical simulation
The average distances between the virtual lines of resection and the actual lines of resection at the three locations examined were all within 3.5 mm.

2: Virtual surgical simulations
The usefulness of virtual surgical simulations as educational tools for skull base and middle ear surgeries have also been reported.1,2)

3: Important roles of pre-operative surgical simulation
The first is to depict the 3D surgical anatomy of the skull base and to conceive the surgical plan. The second role, which was a main emphasis of our study, is to provide a means of feedback to assess the quality of the actual surgery, that is, to verify the differences between the surgical simulation and the actual surgery. When validation of the quality of the actual surgery is possible, the simulation is truly useful.

Conclusions

Pre-operative surgical simulation → Post-operative feedback

Fig. 1 Pre-operative 3D virtual surgical simulation
(a) 3D virtual image.
(b) Translucent image. Bone regions are translucence.
(c) Side-by-side images for stereoscopic viewing.
(d) Virtual resection of the zygomatic process (arrows).

Fig. 2 The main osteotomy lines for en bloc craniofacial resection of advanced sinonasal sinus carcinoma.

Fig. 3 Comparison of lines of osteotomy determined during pre-operative surgical simulation with those of the actual surgery with average measured differences

Fig. 4 CT images of a representative anterolateral craniofacial resection

References