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Navigation-guided en bloc resection and defect reconstruction of craniomaxillary bony tumours

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Abstract. The aim of this study was to evaluate the validity of navigation-guided en bloc tumour resection and defect reconstruction in the treatment of craniomaxillary bony tumours. Three patients with ossifying fibroma and two patients with fibrous dysplasia were enrolled in this study. After preoperative planning and three-dimensional simulation, the osteotomy lines for resection were delineated and the normal anatomic structures for defect reconstruction were ascertained. With the guidance of an Accu-Navi navigation system, an en bloc tumour resection and simultaneous defect rehabilitation were performed. The system provided continuously updated information on the position and movement of surgical instruments in the operating field in relation to the preoperative imaging data set. The system error measured by the computer did not exceed 1 mm. The osteotomy lines and reconstruction contour were checked by postoperative computed tomography, and good matching with the preoperative planning was achieved. Patients showed no signs of tumour recurrence or prosthesis infection during follow-up (range 12–35 months). Image-guided navigation makes radical bone tumour resection more reliable by implementing preoperative planning, showing the determined safety margins, preserving vital structures and guiding reconstruction.

Key words: navigation; craniomaxillary tumour; osteotomy; en bloc resection; reconstruction..

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Tumour resection and primary defect reconstruction requires accurate definition of the intended safety margins, precise location of osteotomy lines, and reliable individual rehabilitation.[1] Bony tumour resection and subsequent custom prosthetic reconstruction has been reported to be complicated as a one-step procedure. With functional and aesthetic considerations, it remains intellectually and technically challenging for even the most experienced surgeon. The surgical results can be compromised despite well-planned operations. There are several factors that contribute to poor outcomes, including surgeon reliance on two-dimensional (2D) imaging for treatment planning on a three-dimensional (3D) object; difficulty in assessing the intraoperative position, projection, and symmetry of the deformed skeletal anatomy; and poor visualization of deep skeletal contours.[2]

Image-guided navigation, with the capability of preoperative planning and intraoperative real-time positioning, has shown great potential for clinical application, particularly when precise location of

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any instrument or bony anatomic landmarks is required.[3,4] In maxillofacial surgery, navigation technology has been widely introduced in procedures such as foreign body removal, deformity correction, and craniomaxillofacial reconstruction.[5,6] However, the validity of navigation in tumour resection has been limited due to the unavoidable deformation and displacement of soft tissues. Craniomaxillary bony tumours, however, have an identifiable margin and relatively stable shape. We investigated the feasibility and validity of navigation in 3D surgical planning and intraoperative navigation for bony tumour resection and primary reconstruction. The en bloc tumour resection was expected to be complicated owing to multiple osteotomies and to custom prostheses that could be fitted into the defect only if the precise amount of bone was resected.

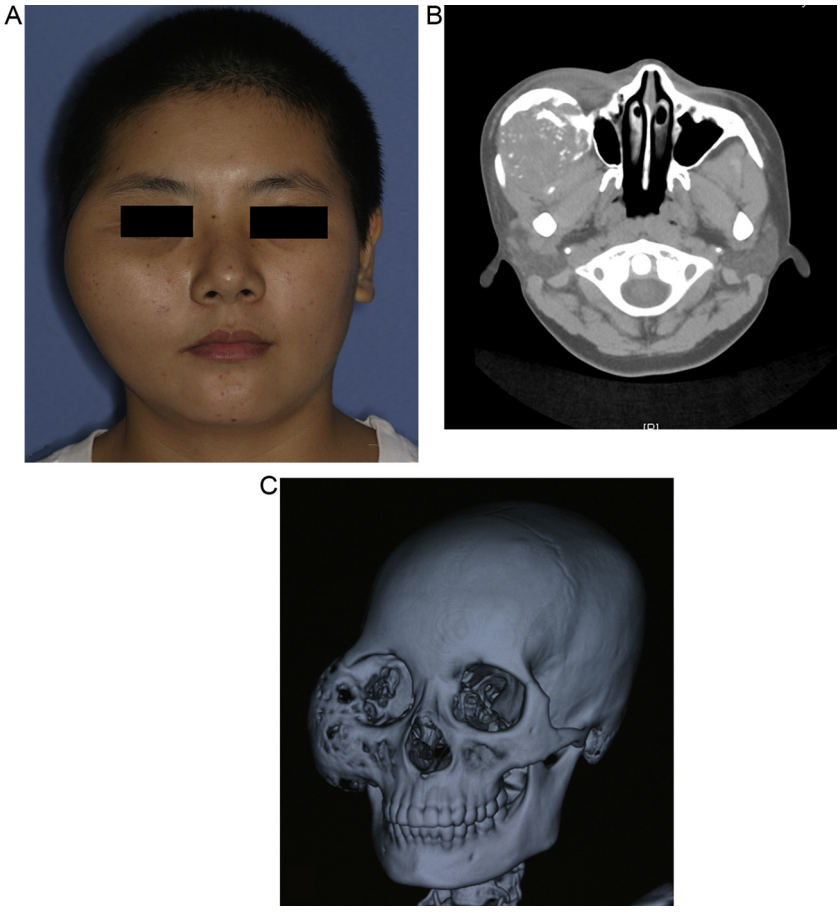

Fig. 1. Facial view and CT images showing an ossifying fibroma on the right craniomaxillofacial side. (A) Front facial view, (B) axial CT image and (C) 3D reconstruction.

Materials and methods

Patients

Three patients with ossifying fibroma and two patients with fibrous dysplasia were referred to the Department of Oral and Craniomaxillofacial Science. The patients (three males and two females) had a median age of 29 years (range 16–47 years). All the lesions were unilateral. The first symptom noticed was asymmetric face with an asymptomatic, slow-growing lesion (Fig. 1). The pathologic diagnosis was confirmed by biopsy performed under local anaesthesia (Table 1). This study had hospital clinical research ethics committee approval and patient informed consent was obtained.

Preoperative planning and simulation

Five position screws were implanted as navigation markers in the maxillary alveolar bone, and a preoperative thin-cut (0.625 mm), spiral computed tomography (CT) scan was obtained (Light Speed 16, GE, Gloucestershire, UK). The data were then transferred to a Windows-based computer workstation with Accu-Navi software (Multifunctional Surgical Navigation System, Shanghai, China). The software converts DICOM data into a proprietary format, compiles the 2D axial images, and presents the data in axial, coronal, sagittal, and 3D reconstructions. The scope of tumour resection was ascertained and virtual surgery was performed. To reconstruct the defect, the median sagittal plane was used as reference plane. Normal anatomic structures and the contour of the target area were mirrored from the unaffected side. Thus the normal contour of the affected area was ascertained (Fig. 2).

Preoperative virtual simulations of the osteotomies, tumour resection, and prosthetic reconstruction were performed. Virtual markers were then placed to mark the position of the planned osteotomy line and tumour resection. Surgical simulation was also performed on the rapid prototyping model according to the preoperative planning. A custom hydroxyapatite (HA) prosthesis preembedded with titanium plates was made (Fig. 3). Once the simulation was completed, the original and simulated virtual data sets were imported into the Accu-Navi navigation system.

Surgery and intraoperative navigation

All operations were performed under general anaesthesia through a nasoendotracheal intubation. The mass was exposed

Table 1. Patient characteristics.

Case No.	Age (years)	Gender	Affected side	Affected area	Pathologic diagnosis	Follow-up (months)
1	20	F	R	Maxilla, zygoma, temporal bone, sphenoid, frontal bone	Ossifying fibroma	24
2	16	M	R	Maxilla, zygoma	Ossifying fibroma	30
3	25	M	L	Maxilla, zygoma	Fibrous dysplasia	12
4	47	F	L	Maxilla, zygoma, temporal bone	Ossifying fibroma	35
5	38	F	R	Maxilla, zygoma, sphenoid	Fibrous dysplasia	24

F, female; M, male; R, right; L, left.