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Technical note

How to perform 3D reconstruction of skull base tumours

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ABSTRACT

The surgical management of skull base lesions is difficult due to the complex anatomy of the region and the intimate relations between the lesion and adjacent nerves and vessels. Minimally invasive approaches are increasingly used in skull base surgery to ensure an optimal functional prognosis. Three-dimensional (3D) computed tomography (CT) reconstruction facilitates surgical planning by visualizing the anatomical relations of the lesions in all planes (arteries, veins, nerves, inner ear) and simulation of the surgical approach in the operating position. Helical CT angiography is performed with optimal timing of the injection in terms of tumour and vessel contrast enhancement. 3D definition of each structure is based on colour coding by automatic thresholding (bone, vessels) or manual segmentation on each slice (tumour, nerves, inner ear). Imaging is generally presented in 3 dimensions (superior, coronal, sagittal) with simulation of the surgical procedure (5 to 6 reconstructions in the operating position at different depths).

1. Introduction

The skull base is a complex region, comprising numerous vessels and nerves and vital structures that must be preserved during surgery. The aim of three-dimensional (3D) tumour imaging of the inner ear and skull base is essentially to facilitate surgical planning.

Three-dimensional reconstruction of the tumour, demonstrating the main anatomical relations with vital structures in all dimensions can be particularly helpful to surgeons before the operation. This technique is mainly indicated in lesions of the jugular foramen (paraganglioma, schwannoma, etc.), lesions of the apex of the petrous temporal bone (epidermoid cyst, cholesterol granuloma, etc.) and skull base meningiomas.

The imaging assessment of these tumours usually comprises a combination of CT and MRI. The 3D reconstruction technique is based on injection of contrast agent at clearly defined times in relation to the arterial and venous phases and manual or automatic segmentation of nerves, vessels, inner ear and the tumour.

2. Technique

Helical CT angiography of the skull base is performed to allow 3D reconstruction on a Philips Brilliance 40-slice scanner or equivalent. This examination was already performed on earlier dual-slice scanners (Philips Twin Flash).

Acquisition comprises a double spiral with arterial and venous phases using the following parameters: pitch: 1, table speed: 2 mm/s, slice thickness: 0.6 mm reconstruction every 0.3 mm, acquisition time (variable as a function of the number of rows), 120 kV, 250 mAs.

Contrast agent is injected by a power injector with the following parameters: 120 cc to 3 cc/s then 30 cc to 1 cc/s, start time of 30 s for the first arterial spiral, 70 s for the second venous spiral. Vessels are well opacified during the two acquisitions with this type of injection (Fig. 1). For tumours with arterial contrast enhancement, such as paragangliomas, the first spiral will be used for reconstruction, while, for tumours with later contrast enhancement (meningiomas or neuromas), the second spiral will be used for reconstruction.

Three-dimensional reconstruction is performed on an image-processing console with Shaded Surface Display (SSD) software

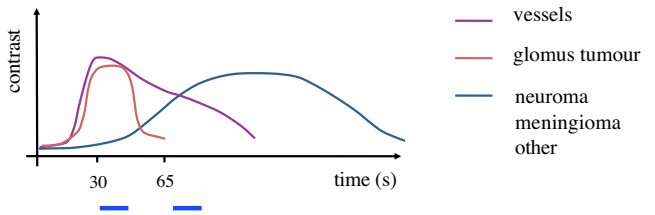

Fig. 1. Temporal characteristics of contrast agent injection.

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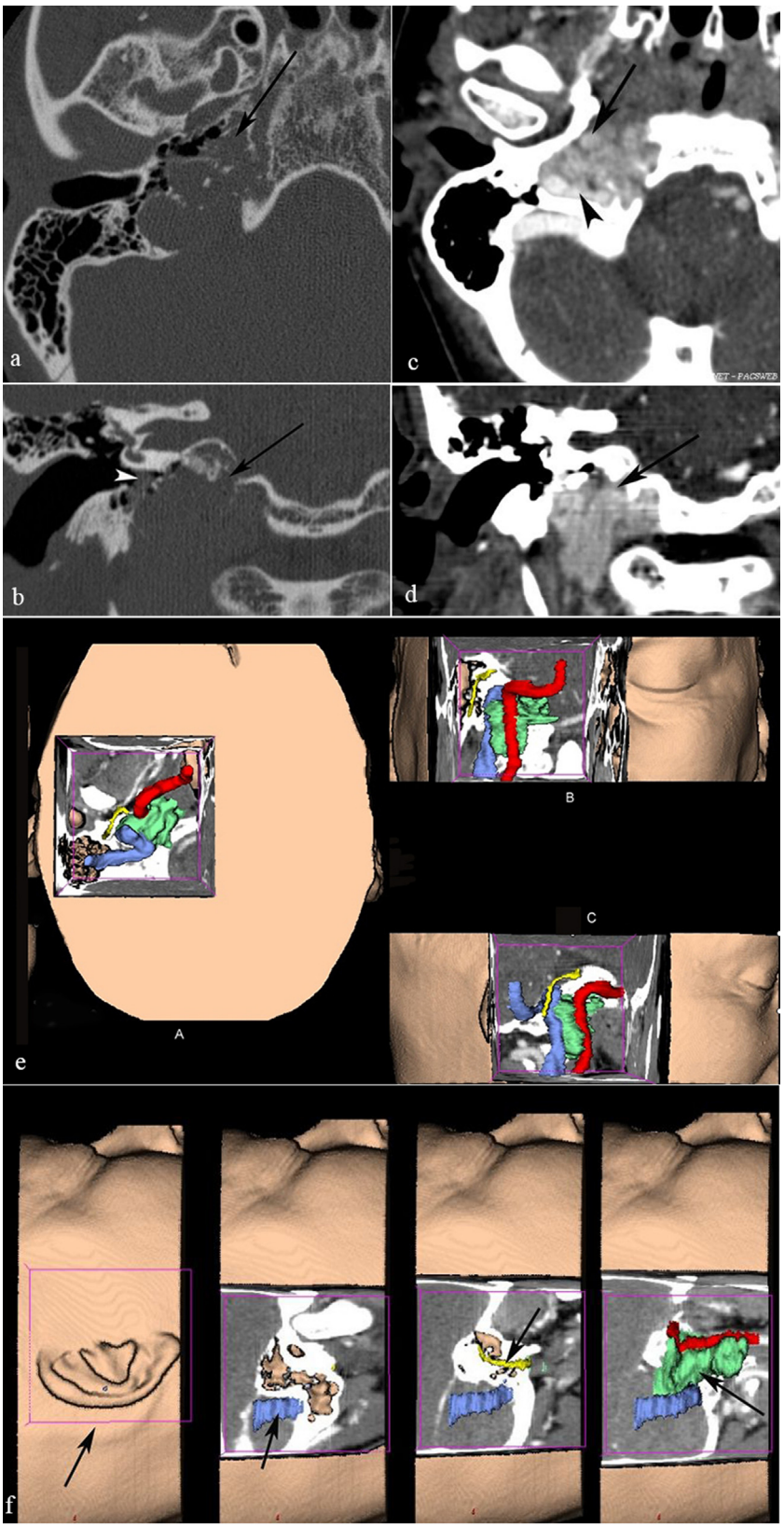

Fig. 2. Clinical case 1. CT scan, axial view: a: unenhanced; c: contrast-enhanced; CT scan, coronal view: b: unenhanced; d: contrast-enhanced; 3D reconstruction: e: A: superior view, B: coronal view, C: sagittal view; f: surgical simulation.

(Philips). All vital structures of the skull base are defined with a specific colour code: carotid vessels are red, the venous system, particularly the jugular vein and sigmoid sinus, are blue, the inner ear is violet, the facial nerve is yellow and the tumour is usually green. This colour coding is performed by segmentation, either by automatic thresholding (mainly for vessels) or manually, slice by slice, for other structures such as the tumour, the facial nerve and the inner ear.

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