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Research Paper
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Surgical safety distances in the infratemporal fossa: three-dimensional measurement study

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Abstract. The wedge-shaped infratemporal fossa is a constricted space and has long been a surgical challenge, mainly due to difficulties in access. Three-dimensional (3D) reconstruction of the skull, internal carotid artery (ICA), and internal jugular vein (IJV) was carried out using enhanced computed tomography (CT) data, to measure the safety distances in relation to infratemporal fossa surgery. Fifty enhanced CT datasets were selected to reconstruct 3D images by segmentation technique. The anatomical routes of the ICA, IJV, and the styloid process (SP) were observed. The following were measured: SP length, height of the pterygoid plates (PP height), distances from the pterygoid process (antero-inferior and anterosuperior border) to the leading edge of the ICA (PP–ICA (inferior), PP–ICA (superior)), and distance between the most prominent point of the zygomatic arch and the medial pterygoid plate (Zyg–MPP). The mean measurements of SP length, PP height, and the distances PP–ICA (inferior), PP–ICA (superior), and Zyg–MPP were 30.64 mm, 26.61 mm, 31.16 mm, 34.37 mm, and 51.37 mm, respectively. No significant differences were observed by age group, except the distance of PP–ICA (inferior) on the left side. In centres without intraoperative navigation facilities, proper knowledge of the anatomy, particularly of bony landmarks and the safe distances to nearby neurovascular structures, can provide useful information to ensure safe operations.

Keywords: infratemporal fossa; three-dimensional reconstruction; skull base surgery.

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The wedge-shaped infratemporal fossa (ITF) is a constricted space located deep in the ramus of the mandible and has long been a surgical challenge, mainly due to difficulties in access. Many experts have proposed various surgical approaches in order to gain better surgical exposure with minimal complications.[1–6] The selection of the surgical approach depends on many factors, including tumour site, location, size, and nature, and its relationship to the surrounding neurovascular structures.[7–10] Surgeon familiarity with the surgical approach to be used is another important factor. With advances in science

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and technology, the development of computer-assisted preoperative planning software has made three-dimensional (3D) observation and simulation of skull base surgeries possible. The computer-designed results can be applied during the operation by the process of navigation.[11–14] Minimally invasive robot-assisted technology is now also used for the removal of ITF tumours.[15–17]

The application of advanced technology definitely has benefits for the patient, however the complexity of the technology and high costs of the equipment impede its widespread use.[18] Where there is a lack of navigation technology for surgery to the skull base, the surgeon is required to be familiar with the accurate anatomy of the ITF. The anatomical structure that the surgeon is most concerned about and fears injuring is the internal carotid artery (ICA). Many measurements have been obtained previously from dry skull, cadaver, and image data to provide reference information.[9,19–21] However, due to the fact that the real position of the ICA during surgery is not identical to that of a dry skull or cadaver, the reliability of the information is weakened. 3D imaging techniques provide extensive possibilities for detailed and precise analysis of the whole craniofacial complex.[22]

In this study, we used enhanced computed tomography (CT) data to form 3D reconstructions of the skull, ICA, and internal jugular vein (IJV), in order to measure safety distances in relation to ITF surgery, and thus to provide reliable information for surgeons operating on the skull base.

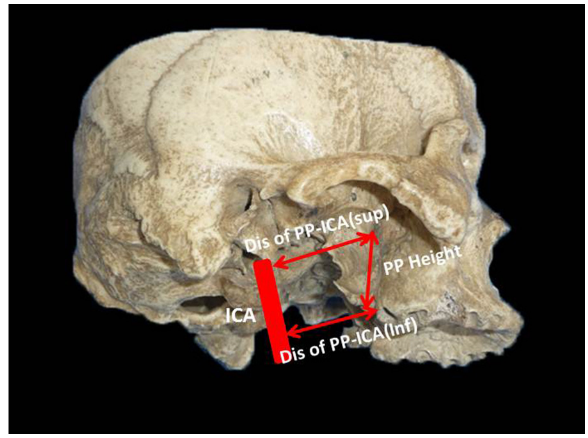

Fig. 1. View of the infratemporal fossa, showing the measurements made and their relationships to important landmarks. 'PP Height' is the height of the pterygoid plates; Distance PP–ICA (superior) and Distance PP–ICA (inferior) are the distances from the pterygoid process (anterosuperior and antero-inferior borders, respectively) to the leading edge of the internal carotid artery; ICA is the internal carotid artery.

Materials and methods

The research was approved by the institutional biomedicine ethics committee. Fifty datasets (19 from females and 31 from males) of enhanced CT data (BrightSpeed; GE Healthcare, USA) were selected; the exposure was extended from the infrahyoid to the supraorbital region. A slice thickness of 1.25 mm is commonly requested for enhanced CT scans used for 3D reconstruction. Patients had to meet the following selection criteria: (1) adult, (2) disease sparing the ITF, ICA, and IJV, and (3) no past history of such an operation. An experienced radiologist assisted in the exclusion of cases who did not qualify.

After importing the acquired CT data into iPlan software (Brainlab, Feldkirchen, Germany), information including the patient's age and gender was recorded. During the reconstruction process, the enhanced CT data were used to reconstruct a 3D image of the ICA, IJV, and skull bone by segmentation technique. Manual alignment was sometimes necessary to provide a better image. The anatomical routes and diameters of the ICA and IJV, the relationship between the ICA and IJV, and the level of the position of the styloid process (SP) tip were observed.

The following variables were measured: SP length, the height of the pterygoid plates (PP height), distances from the pterygoid process (antero-inferior and anterosuperior border) to the leading edge of the ICA (PP–ICA (inferior) and PP–ICA (superior), respectively), and the distance between the most prominent point of the zygomatic arch and medial pterygoid plate (Zyg–MPP) (Figs. 1 and 2).

SPSS version 14.0 software (SPSS Inc., Chicago, IL, USA) was used for the statistical analysis. Independent sample *t*-tests (comparisons between the left and right sides), paired samples *t*-tests (comparisons between the genders), and one-way analysis of variance (ANOVA) tests (comparisons between age groups) were performed to determine statistically significant differences ($P < 0.05$).

Results

The mean age of the 50 patients was 43.02 years (range 17–77 years). The anatomical routes and relationships of the ICA, IJV, and styloid process observed on 3D images are detailed in Table 1 and shown in Figs. 3–7.

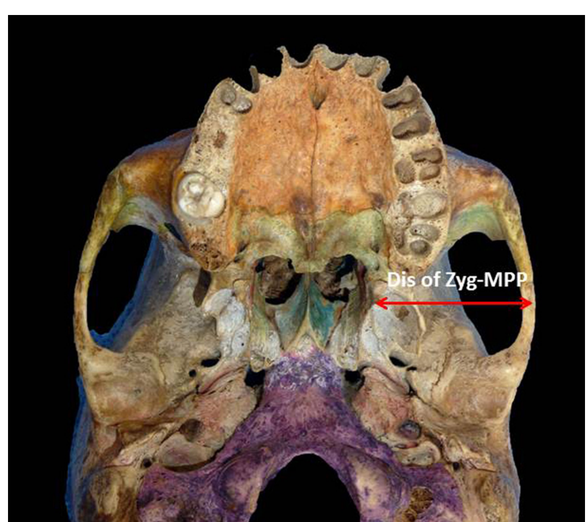

Fig. 2. View of the skull base showing the distance between the most prominent point of the zygomatic arch and the medial pterygoid plate (Zyg–MPP).