Transsphenoidal surgery utilizing computer-assisted stereotactic guidance*

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SUMMARY

Computer-assisted guidance technology represents the next step in the application of stereotactic techniques to skull base surgery. Use of this 3-D technique reduces operative time and complications as the technique allows a more direct approach with precise real-time anatomical guidance. We present seven cases of transsphenoidal parasellar surgery where this technique has been employed. The pathology included lesions of the sella turcica, parasellar region and the petrous apex.

Key words: stereotactic surgery, petrous apex, parasellar region

INTRODUCTION

Surgical techniques using stereotactic systems permit the surgeon to perform biopsies and resections of deep-seated and previously inaccessible lesions (Roberts, 1986). This is achieved by integrating information derived from imaging studies into an actual 3-D image of the operative field.

There are two types of stereotactic systems currently in use: frame and frameless. Both frame and frameless systems utilize reference points that are visualized on the imaging study.

The older stereotactic frames established a reference point through an apparatus rigidly attached to the patient's head. This permitted the surgeon to define the sagittal, coronal and axial planes or the "X" "Y" and "Z"- axis's. These systems were invasive, cumbersome to apply and created obstacles within the surgical field.

Frameless systems utilize a computer-generated image of the patient based on an imaging study, such as an MRI. The "X', "Y" and "Z" axis's are determined from the exact location of at least five reference points which have been placed onto to the patient's scalp prior to a perioperative imaging study. These reference points or markers are usually small beads composed of material that is obvious on either computerized tomography (usually metal) or magnetic resonance imaging (usually a fat-like substance such as vitamin E capsules). After the imaging study is completed, it is transferred to a computer workstation either by a cable, digital magnetic tape or optical disc. The computer then utilizes software to create a three-dimensional picture of the patient's head. In the operating room, an array of sensors is placed around the patient's head. These are lower than the operative field and pose no physical obstacle to the surgeon. A probe will be used in the operative field. This probe is an instrument that sends a signal to the array of sensors around the head. The location of the probe is superimposed on the computer generated 3-D image on the monitor. This 3-D image is matched with the real head of the patient using the reference markers placed for the perioperative study. This information allows for actual comparison of the patient and the computer generated 3-D image. The localizing probe accurately pinpoints anatomical locations in this 3-D space down to 1mm (Youmans, 1982; Golfinos, 1995). This intraoperative "map" helps the surgeon avoid vital structures such as the carotid artery, dura, cavernous sinus and optic nerve, reducing intraoperative morbidity and operative time.

MATERIAL AND METHODS

Seven patients underwent frameless stereotactic surgery for skull base lesions at Lenox Hill Hospital and New York Hospital in New York City from 1994-98. Ages varied from 28 to 60 years. All patients had a sublabial, trans-sphenoidal approach for removal of pituitary adenomas, meningiomas and

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Table 1. Case outlines.

	Lesion	System used	CT or MRI scan	Complication
1	Cholestorol granuloma	Zeiss	CT	None
2	Petrous apex meningioma	SNT	MRI	CSF leak
3	Cholestorol granuloma	SNT	MRI	None
4	Cholestorol granuloma	SNT	MRI	None
5	Petrous apex meningioma	SNT	MRI	CSF leak
6	Pitutary Adenoma	SNT	MRI	None
7	Pitutary Adenoma	SNT	MRI	None

SNT - Surgical Navigation Technologies, MRI - Magnetic Resonance Imaging, CSF - Cerebrospinal Fluid

cholesterol granulomas of the petrous apex (Table 1).

MRI or CT scan Imaging studies were obtained the night before or on the morning of the procedure after application of the five reference markers. The data from the imaging study was transferred to digital magnetic tape or optical disc and transported to the operating room for computer generated reconstruction. Once loaded onto and processed by the computer workstation, the MRI or CT scan study was represented in three planes (coronal, sagittal and axial) and rendered into a 3-D image of the patient.

The frameless system used in this study was the Zeiss Navigation system (Carl Zeiss, Thornwood, NY, USA; now distributed by Surgical Navigation Specialist, Mississauga, ON, Canada) or the Surgical Navigation Technologies (SNT,

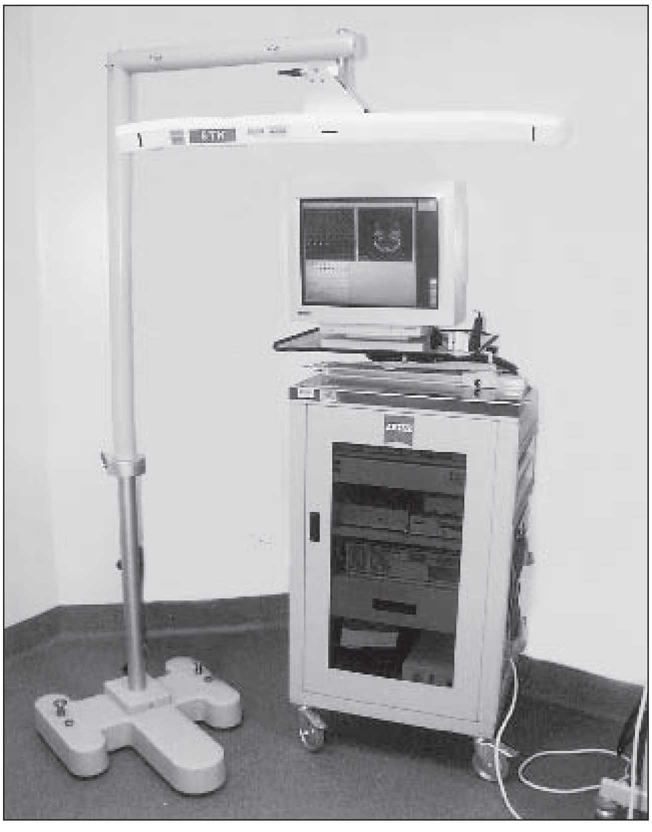

Figure 1. The processing unit and screen of the Zeiss system.

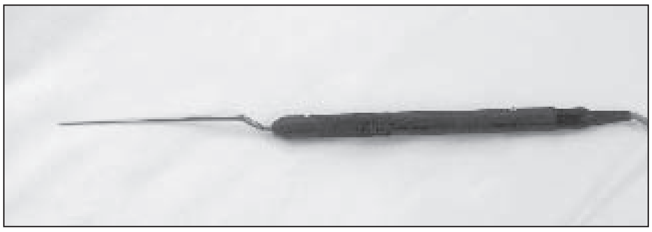

Figure 2. Localization wand with Light emitting diode array.

Boulder, CO, USA) (Figure 1). A localizing probe was used with a three-dimensional digitizing system (Figure 2). This probe sent a signal to an array of sensors around the patient's head. Analog digital converters transferred the data from the sensors to an interface processor that calculated the position of the tip of the probe. The position of the probe tip was transferred to an image processor that displayed its location superimposed on the computer generated 3-D image 3-D of the patient's head. The 3-D image was then used in conjunction with the operating microscope to confirm the surgical location. The system was registered at the beginning of the operation by touching the probe tip to the previously applied reference

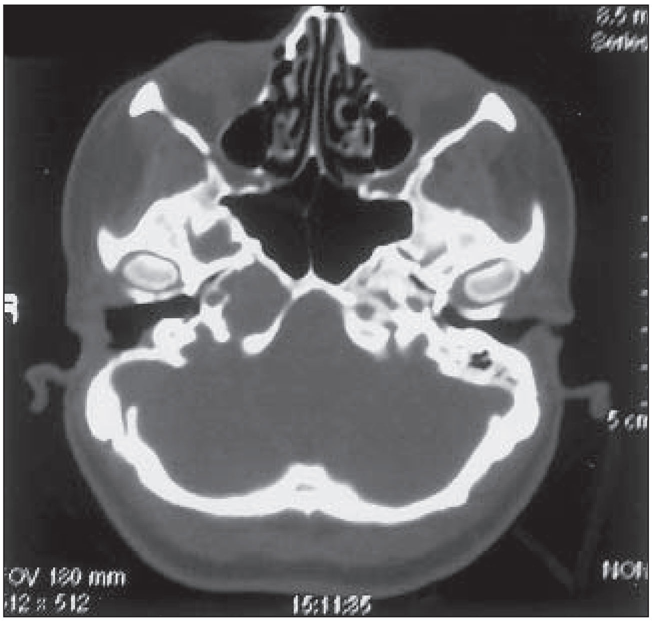

Figure 3. CT scan showing a large petrous apex cyst.

markers. The system automatically calculated error, using a reference point protocol, which was incorporated into the proprietary software. The difference between the 3-D image and real location of the probe tip was the error and was expressed in millimeters.

CASE REPORTS

Case 1

A 28-year old female presented with severe headaches on the left side. Clinical examination was unremarkable. A CT scan done showed a petrous apex cyst consistent with a petrous apex cholesterol granuloma (Figure 3). She underwent a

Figure 4. An intra-operative picture showing a patient with markers and sensor array in place.

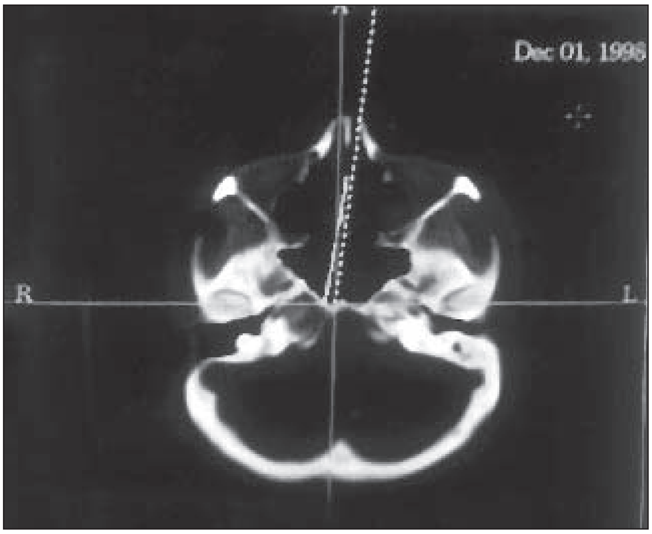

Figure 5. Photograph of the monitor showing intraoperative localization and guidance.

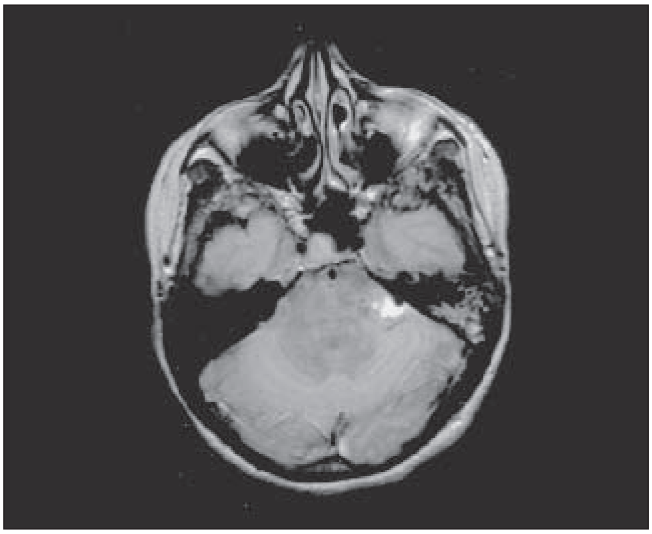

Figure 6. MRI (without contrast) showing the parasellar meningioma.

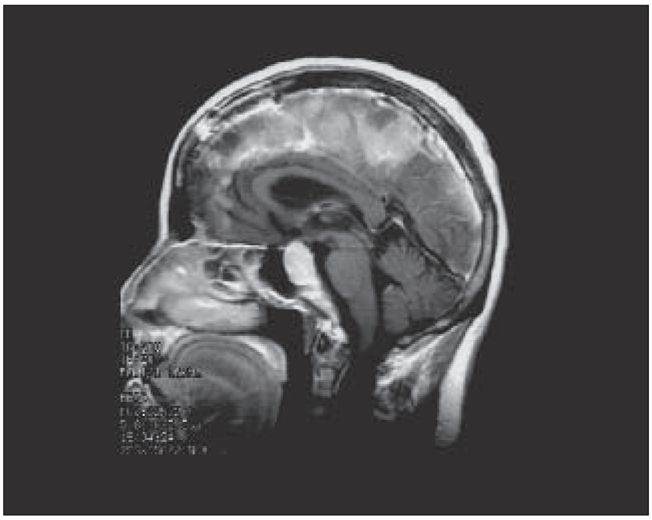

Figure 7. MRI (with contrast) showing the parasellar meningioma.

transsphenoidal 3-D stereotactic drainage of the granuloma into the sphenoid sinus (Figures 4 and 5). She did well and is currently free of her headaches.

Case 2

A 50-year old male presented with decreasing vision on the left side with an associated visual field deficit. A MRI scan revealed a meningioma located beneath and lateral to the optic nerve just behind the tuberculum sella (Figures 6 and 7). He underwent a transsphenoidal 3-D stereotactic excision of the lesion. This surgical approach allowed visualization and preservation of both the hypophysis and the optic nerve. An intra-operative CSF leak was closed using fibrin glue and fat. The morbidity of a craniotomy was avoided. The patient did however develop CSF rhinorrhea that was subsequently surgically treated and resolved.

RESULTS

In the seven cases where this stereotactic system was employed the error in the true position of the probe tip varied from 1.5 to 2.5 mm. The system was not used if the error exceeded more than 2.5mm. In none of the cases was the limit exceeded. There were no complications related to the localization. Two patients with basal meningioma had post-operative CSF leaks, which were managed surgically. This is a known and often unavoidable complication of surgery of such meningiomas as the meninges are removed along with the tumor.

DISCUSSION

Lesions of the sella turcica, parasellar region and petrous apex can be approached in a number of ways. Access to these areas can require extensive surgical procedures, which are time consuming and associated with significant morbidity.

Glasscock described approaches to the petrous apex which included: mastoidectomy, with the opening of several air cell tracts toward the petrous apex, labyrinthectomy with posterior transposition of the facial nerve (in patients with hearing loss), middle fossa and suboccipital approaches (Glasscock, 1990).

Other approaches for sellar and parasellar lesions include: the paramedian subfrontal approach described by Adson (1918), the sub-frontal approach described by Horsley (1906), and the transylvian and transsphenoidal approaches.

In an effort to reduce operative time and morbidity we combined the conventional transsphenoidal approach with the guidance of a computer-assisted three-dimensional localizing system. This provided dynamic guidance, improved operative efficiency, and helped the operating surgeon avoid critical structures. It also avoided the need for intraoperative fluoroscopy and thus reduced X-ray exposure to the patient and O.R. staff. Like other frameless stereotactic systems, the infrared-based guidance system provided real time anatomical and positional information. Minimal additional effort was required from the surgeon when a technician prepared the imaging data set and helped to maintain the viewing system in and out of the operating room. On average, intraoperative setup varied between 20 to 30 minutes, while improved accuracy and decreased surgical exposure lessened operative time dramatically. The system was sufficiently accurate for reliable intraoperative localization and guidance (Zinreich, 1993). We feel that the utilization of the frameless stereotactic system will increase the ease and efficiency of skull base surgery.

CONCLUSION

Frameless three-dimensional computer-assisted guidance technology represents the next step in the application of newer techniques to skull base surgery. The SNT system and Zeiss system provided sufficiently accurate intraoperative guidance in our cases to allow constant updating of the surgeon's intra- and extracranial position with regard to the pathological lesion and surrounding normal structures. We would expect that given enough time and a sufficiently large patient population, outcome measures such as complication rate would be more favorable in cases in which frameless stereotactic techniques are used.

REFERENCES

1 Adson AW (1918) Hypophysial tumors through the intradural approach. Journal of American Medical Association. 71: 721-726.

2 Glasscock and Shambaugh (1990) Surgery of the Ear. Philadelphia, W.B. Saunders Co., 567-568.

3 Golfinos JG, Fitzpatrick BC, Smith LR, Spetzler RF (1995) Clinical use of a frameless stereotactic arm: results of 325 cases. Journal of Neurosurgery 83: 197-205.

4 Horsley V (1906) On the technique of operations on the central nervous system. British Medical Journal 2:411-423.

5 Roberts DW, Strohbehn JW, Hatch JF (1986) A frameless stereotaxic integration of computerized tomographic imaging and the operating microscope. Journal of Neurosurgery 65: 545-549.

6 Youmans JR (1982) Neurological surgery. Philadelphia, W.B. Saunders Co. Pages 3107-3162.

7 Zinreich SJ, Tebo SA, Long DM, (1993) Frameless stereotaxic integration of CT SCAN imaging data: accuracy and initial application. Radiology 188: 735-742.

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