Image guidance in trans-sphenoidal surgery for giant pituitary adenomas: Luxury or necessity?

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ABSTRACT

Background: In spite of availability of image guidance (neuronavigation) at major centers around the world, most trans-sphenoidal surgeries for pituitary adenomas continue to be done under fluoroscopic control. On the other hand, the high mortality and morbidity for giant pituitary adenomas is mainly due to inadequate tumor removal. **Aims and Objectives:** The objective of this study was to study to utility of image guidance in trans-sphenoidal surgeries for optimizing tumor removal in giant pituitary adenomas. **Materials and Methods:** This was a prospective study carried out over a two years (January 2009-December 2010) in the Department of Neurosurgery, All India Institute of Medical Sciences. Patients with giant pituitary adenomas who underwent trans-sphenoidal surgery by the author were included. All surgeries were done under image-guidance only and no fluoroscopy was employed. Trajectory was defined using the image guidance and bone work done accordingly to optimize tumor removal. All patients had a contrast CT of the head done within 48 h of surgery to see for residual tumor. **Observations and Results:** Sixteen patients with pituitary adenomas were operated using only image-guidance in the study period. Twelve patients had virgin tumors and four patients had recurrent/residual tumors. In four patients, noncontrast MR images were used in for image guidance and contrast CT images were used in the rest. The mean set up time for image-guidance was 11 min (range 7–15 min). The mean ''overall accuracy of registration'' was 1.6 mm (range 1.4–2.1 mm). The mean operating time was 72 min (range 52-96 min). In all cases, midline and the relation of the carotid artery to the sella could be confirmed using the image-guidance. There were no intraoperative complications. Postoperative scans showed residual tumor in nine patients. The residual tumor was <10% in four patients, <25% in four patients and >25% in one patient (with a fibrous recurrent/residual tumor). **Conclusions:** Image guidance markedly improves the visualization of sellar floor and its relation to the carotid arteries, thereby improving the safety and quality of the surgical procedure, besides being free of limitations of fluoroscopy. More importantly the trajectory can be defined for optimizing tumor removal in such patients. Image-guidance can easily replace flouroscopy for trans-sphenoidal surgeries and when available should be the first choice when operating pituitary tumors trans-sphenoidally.

Key words: Giant pituitary adenoma, image guidance, neuronavigation, trans-sphenoidal

INTRODUCTION

In spite of advances in management, hormonally nonfunctioning giant pituitary tumors carry a significant surgical mortality and morbidity.[1] One of the main reasons for exceptionally high morbidity is inability to remove the tumor completely resulting in intraoperative and postoperative tumor swelling, direct compression on hypothalmus and acute elevation of the intracranial pressure.[2-5]

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Most giant pituitary adenomas continue to be operated transsphenoidally.[6] Although considered satisfactory, trans-sphenoidal surgery under fluoroscopic control has several limitations such as risk of radiation exposure to operating room personnel, only two-dimensional images of bony anatomy being available, and inability to confirm midline access to sella and relation to critical structures such as carotid arteries. In addition, this method leads to fatigue amongst the operating room personnel as lead aprons have to be worn throughout the procedure. Image-guided surgery or neuronavigation has become a necessary part of the neurosurgical armamentarium in most centers around the world, primarily because it helps in improving patient safety and consistency of surgical results.[7-11] However, despite its availability in many centers, patients undergoing trans-spenoidal pituitary surgery continue to be operated under fluoroscopy-presumably due to lack of its perceived

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benefits. This study was therefore planned to assess the usefulness of image guidance in trans-sphenoidal surgery for giant pituitary tumors.

MATERIALS AND METHODS

This was a prospective study carried out over a 12-month period in the department of Neurosurgery, All India Institute of Medical Sciences. Patients with hormonally non-functioning pituitary adenomas who underwent trans-sphenoidal surgery by the author were included in the study. All surgeries were done under image-guidance only (Medtronic Inc., Memphis, TN) and no fluoroscopy was employed. Time for setting up image guidance inside the operating room, overall accuracy of registration (OAR), midline access, and visualization of relation to carotid arteries and intra-operative complications were assessed. Trajectory was defined using the image guidance and bone work done accordingly to optimize tumor removal. All patients had a contrast CT of the head done within 48 h of surgery to see for residual tumor. The completeness of tumor decompression was classified on CT arbitrarily into four grades: grade 1-Complete removal with no residual tumor; grade 2-residual tumor <10% of the original; Grade 3-residual tumor >10% but <25% of the original; grade 4-residual tumor >25% of the original.

Technique

MRI or CT head were done with the fiducials placed on the scalp, either a day prior to, or in the morning of surgery. MRI is considered to be superior as no radiation is involved and the anatomy is better defined. However, in our experience, contrast CT is far cheaper and simpler to arrange and shows the bony anatomy exquisitely. Internal carotid arteries and their relation to the sellar walls are also very well visualized. The fiducials are applied on the forehead, zygomatic process and mastoid bilaterally [Figure 1]. This placement avoids any need for shaving hair and provides for easy registration. To minimize radiation exposure, only the region of interest (hard palate to superior extent of the tumor) is included when doing the CT [Figure 2]. This is also made possible by the novel placement of fiducials which make full head acquisition unnecessary. After transferring the images to the stealthstation, the head is fixed in a Mayfield clamp and registration is done in the usual manner. Head movements are easily controlled by moving the table. As fluoroscopy is not used, draping the patient is simpler and there are less chances of breaching the sterile field [Figure 3]. Finally, the trajectory was defined using the image guidance and bone work done accordingly to optimize tumor removal.

Figure 1: Photograph showing placement of the fiducials and patient positioning for image guided trans-sphenoidal surgery

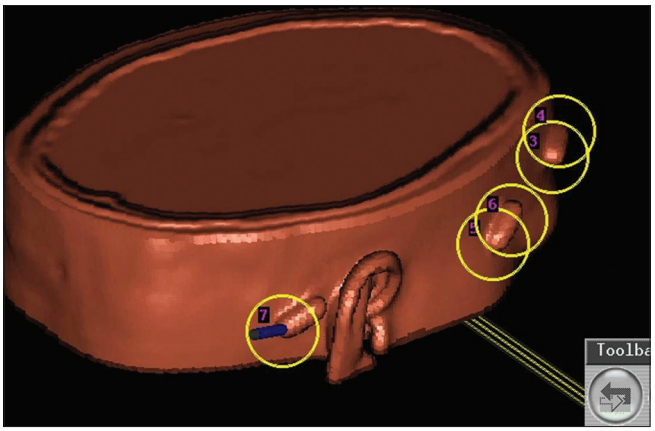

Figure 2: The novel placement of fiducials allows us to take a smaller slab during CT imaging minimizing radiation exposure to the patient without affecting registration accuracy

Figure 3: Without fluoroscopy there is ample room for the microscope and surgeon to operate with ease

OBSERVATIONS AND RESULTS

Sixteen patients with pituitary adenomas were operated using only image-guidance in the study period. Twelve

patients had virgin tumors and four patients had recurrent/residual tumors. In 4 patients non-contrast MR images were used in for image guidance and contrast CT images were used in the rest. The mean set up time for image-guidance was 11 min (range 7–15 min). The mean 'overall accuracy of registration' was 1.6 mm (range 1.4–2.1 mm). In all cases, the midline and the relation of the carotid artery to the sella could be confirmed using the image-guidance which markedly helped in increasing the bony opening laterally, thereby improving the lateral access to the pituitary adenoma. The mean operating time was 72 min (range 52–96 min). In all cases, midline and the relation of the carotid artery to the sella could be confirmed using the image-guidance. There were no intraoperative complications. Postoperative CT head showed residual tumor in nine patients. The residual tumor was <10% in four patients [Figures 4a and b], <25% in 4 patients and >25% in one patient (with a fibrous recurrent/residual tumor)

In spite of a grade 4 excision, the patient had improvement in visual acuity and fields postoperatively, possible due to sagging of the tumor through the wide sella floor opening which was made possible due to the use of image guidance.

DISCUSSION

The goal in using neuronavigational instrumentation during transsphenoidal surgery is to increase the accuracy of the approach, thus making it less invasive and safer, while simultaneously decreasing the time needed for surgery and preoperative planning.[12,13] Trans-sphenoidal surgery is especially suitable for image guidance as the bony landmarks remain constant throughout the procedure and more importantly the relationship of critical structures like carotid artery and cavernous sinus to the bony landmarks is not affected by the procedure. Because of this three dimensional view of the approach is available virtually in real time. One of the reasons some neurosurgeons continue to use fluoroscopy is the unfamiliarity with image guidance and perceived lack of its benefits. As our study shows, image guidance besides being very easy to set up and use, improves the accuracy of the approach and may actually decrease the total surgical time as compared to fluoroscopy-based procedures. In tertiary care centers and academic institutions, image guidance can also improve the consistency of operative results by providing inexperienced surgeons and residents control over the midline approach in trans-sphenoidal surgeries. Another advantage of image guidance is that it can be used in both microscopic as well as endoscopic procedures, especially in recurrent tumors where anatomy may be very distorted.

We have found image-guidance to be particularly useful in giant as well as recurrent pituitary adenomas as it helps in increasing the lateral sella opening without risk of injuring the carotid arteries. This improves the access to the pituitary adenoma and results in better tumor removal. Once inside the tumor, the technique of tumor removal remains the same with the anterior most part being removed last to prevent arachnoid bulge and consequent loss of operative field of view. All three giant pituitary adenomas in our study could be decompressed adequately with residual volumes on postoperative CT being less than 25%. Also, if the bony opening is adequate, even tumors which are very fibrous and firm may 'fall down' leading to symptomatic improvement postoperatively (as seen in one patient with fibrous tumor in our study).

Trans-sphenoidal surgery in recurrent tumors is considered more risky due to disruption of midline structures and adhesions. Here too, image guidance can be extremely helpful in maintaining midline trajectory and ensuring adequate tumor removal. In all cases in our study the midline and the relation of the carotid artery to the sella could be confirmed using the image-guidance. Although the number of patients studied is small, we believe that the results will be valid over a larger cohort of patients.

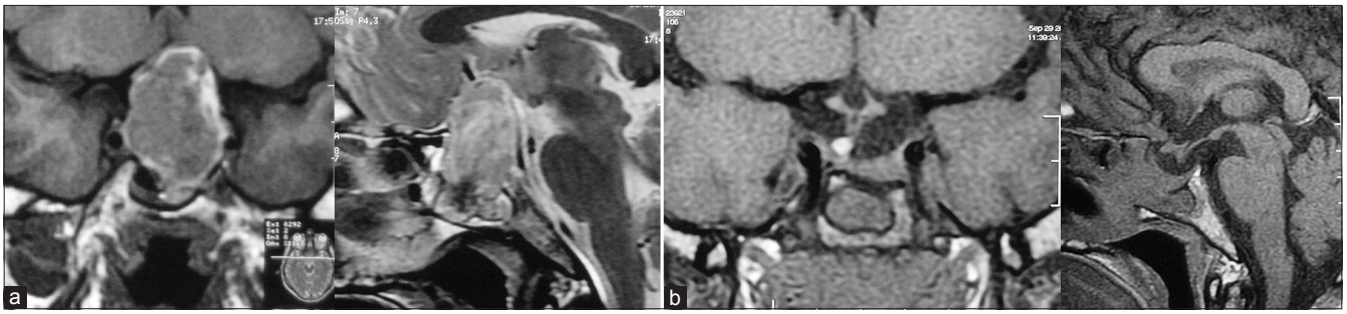

Figure 4: (a) Representative preoperative MRI (T1 coronal and T2 sagittal cuts) of a patient with giant non-functioning pituitary adenoma (b) The postoperative MRI (T1 coronal and sagittal cuts) of the same patient showing gross total tumor removal following image guided trans-sphenoidal surgery

We did not face any problems in arranging imaging for image guidance with the fiducials in place and this in part may be due to our preference for CT over MRI. However, in order to obviate the need for preoperative scanning fluoroscopically guided navigation (flouronav on stealthstation) may be used. Although providing three dimensional views this also suffers from all the other limitations of fluoroscopy including radiation exposure and non-visualization of the important neurovascular and soft-tissue structures of the brain.[11] An extra benefit of using image guidance as a standalone system in trans-sphenoidal surgery is that it frees up the fluoroscope for use elsewhere. This can be particularly useful in a busy neurosurgery practice such as ours where multiple neurosurgery operations theatres are running simultaneously and equipment use needs to be judicious. Thus, by using the image guidance system and fluoroscope independently, the return on investment can also be optimized.

CONCLUSIONS

Image guidance markedly improves the visualization of sellar floor and its relation to the carotid arteries, thereby improving the safety and quality of the surgical procedure, besides being free of limitations of fluoroscopy. Image-guidance can easily replace flouroscopy for trans-sphenoidal surgeries and when available should be the first choice when operating giant pituitary tumors trans-sphenoidally.

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