Endoscopic Sellar, Suprasellar and Parasellar Surgery with Image Guidance

HESHAM M. NEGM, M.D.*; HUSSAM M. EL-BOSRATY, M.D.*; HAZEM A. BADIEA, M.D.** and MINA S. FAHIM, M.Sc.*

The Departments of Otorhinolaryngology* and Neurosurgery**, Faculty of Medicine, Cairo University

Abstract

Objective: This study was conducted to assess the efficacy of using image-guided systems in endoscopic sellar, suprasellar & parasellar surgeries.

Material and Methods: The study included 20 patients presented with sellar, suprasellar and parasellar pathologies. Patients were divided into 2 groups: Study group, which included 10 patients who were operated upon using the image-guided system (IGS) and control group, which included 10 patients who were operated upon without using the IGS. The main outcomes measured were major complications, average blood loss, and operative time.

Results: The study group had one major complication; an average blood loss of 840ml, and an average total operative time of 166 minutes. The control group had three major complications; an average blood loss of 818ml; and an average total operative time of 154 minutes.

Conclusion: The use of an image-guided system for endoscopic transsphenoidal surgery may reduce the complications associated with the procedure and allow for a more thorough operation. However, operative time and blood loss may be increased.


Introduction

The sella is located in the center of the cranial base. Access to the sella is limited from above by the optic nerve, optic chiasm and circle of Willis, laterally by the cavernous sinuses and internal carotid arteries, and from behind by the brain stem and basilar artery [1].

The endoscopic endonasal approach to the sellar region is a recent evolution of the conventional transsphenoidal technique performed with the operating microscope. It is rapidly gaining wide acceptance due to its excellent capacity to explore the sphenoid sinus, the pituitary fossa and the suprasellar and parasellar spaces. The prominent features include minimal invasiveness and a close-up panoramic view, which may result in more complete removal of invasive tumors, reduced postoperative discomfort and shortened hospital stay [2]. Unfortunately, the rigid-lens system provides only a two-dimensional view, requiring surgeons to localize instruments based on their depth of penetration and tactile sensation. Orientation and localization within the sphenoid sinus and sellar cavity can be problematic, especially in the setting of extensive disease, revision surgery, or bleeding. Due to the close proximity of important orbital and intracranial structures, complications from transsphenoidal surgery, although rare, can be devastating [3,4].

The technology of Image-Guided Systems (IGS) has served to fuel the dynamic evolution of endoscopic transsphenoidal surgery. Image-guided systems were developed to provide assistance with real-time intraoperative localization of surgical anatomy. These systems function to identify surgical instruments, calculate the location of the instrument tip in relation to the patient, and project the instrument location onto a previously obtained imaging study (a CT scan or MRI). The combined use of image guidance and endoscopy is the newest advance in transsphenoidal surgery [5].

The aim of this work is to evaluate the efficacy of image-guided systems in endoscopic sellar, suprasellar and parasellar surgeries.

Material and Methods

This study was conducted on 20 patients presented with sellar, suprasellar and parasellar pathologies admitted in the Otorhinolaryngology and
Neurosurgery Departments, Faculty of Medicine, Cairo University in the period between January 2013 and July 2014. All patients were subjected to preoperative evaluation in the form of careful history taking; rhinological, ophthalmological and neurological examination; radiological and laboratory investigations. The radiological investigations included CT scan of the nose, paranasal sinuses and brain, coronal, axial and/or sagittal cuts, soft tissue and bone windows (± IV contrast) (Navigation system protocol); and MRI scan of the nose, paranasal sinuses and brain. Laboratory investigations include routine preoperative laboratory investigations; and hormonal assay for ACTH, cortisol, TSH, free T3, free T4, FSH, LH, growth hormone and prolactin.

Patients were divided into 2 groups: The study group, which included 10 patients who were operated upon using the Image-Guided System (IGS), and the control group, which included 10 patients who were operated upon without using the IGS.

Operative technique:

All patients were operated using the “Endoscopic Endonasal Transsphenoidal Approach”. The procedure was performed under general anesthesia, with the patient in a supine position and the head slightly elevated (anti Trendelenberg position). The patients in the study group were operated using an optical-based image-guided system. A headset with reflective spheres was tightly secured over the forehead of the patient. After that a process of paired-point registration was started by defining fiducial points in the imaging data set. Anatomic points (such as medial and lateral canthus, the root and tip of the nose) were used as fiducial points. Then the surgeon manually mapped corresponding fiducial points in the operating field volume with a tracked probe. At last, the computer performed the registration by aligning corresponding points in the preoperative imaging data set and the operative field volume.

The parameters evaluated intraoperatively comparing the 2 groups of patients were intraoperative complications, operative time, and average blood loss. Intraoperative complications include major vessel injury, injury to the optic nerve, iatrogenic CSF leakage, and injury to the intracranial structures. Time parameters were measured in minutes for two categories: Total operative time and actual operative time. The total operative time is that spent by the patient in the operating room reflecting anaesthesia and surgery times, as well as time for the setup and operation of the image-guidance system, including placement of the patient headset, calibration and registration of the handheld probes, and use of the system for anatomical localization throughout the procedure. The actual operative time is that spent from the start to the end of the surgical procedure.

Results

The IGS group (study group) included 10 patients, 6 males and 4 females with a mean age of 38 years; range 19-59 years. Surgical indications included pituitary adenoma (8 cases) Figs. (1,2), clival chordoma (one case) Fig. (3), meningioma (one case). The control group included 10 patients, 6 males and 4 females with a mean age of 34.5 years; range 21-60 years. Surgical indications included pituitary adenoma (7 cases), clival chordoma (1 case), meningioma (1 case), suprasellar dermoid cyst (1 case).
The mean total operative time was greater for the IGS group (166 minutes; range 105-250 minutes) than for the control group (154 minutes; range 90-210 minutes). However, the mean actual operative time was less for the IGS group (130.5 minutes; range 75-210 minutes) than the control group (138 minutes; range 75-190 minutes). These differences between the IGS and the control groups were not statistically significant. The mean intraoperative blood loss was higher for the IGS group (840ml; range 390-2000ml) than the control group (818ml; range 260-2500ml). This was not a statistically significant difference (Table 1).

The IGS group had 1 major complication (10%) in the form of intraoperative bleeding from intradural vessels that was controlled by packing with surgicel and applying gentle pressure with a cottonoid. However, the control group had 3 major complications (30%) in the form of postoperative CSF leak (2 cases) and intraoperative bleeding (1 case) due to carotid artery injury that required blood transfusion and firm packing with gel foam and surgicel and the procedure was not completed. This difference in major complications between the IGS and the control groups was not statistically significant ($p$-value = 0.26).

Table (1): Numerical parameters of the IGS and control groups.

<table>
<thead>
<tr>
<th></th>
<th>IGS (Study) group (n=10)</th>
<th>Control group (n=10)</th>
<th>$p$-value</th>
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<tbody>
<tr>
<td></td>
<td>Mean ± SD</td>
<td>Range</td>
<td>Mean ± SD</td>
</tr>
<tr>
<td>Total operative time</td>
<td>166±44.27</td>
<td>105-250</td>
<td>154±42.32</td>
</tr>
<tr>
<td>Actual operative time</td>
<td>130.5±41.19</td>
<td>75-210</td>
<td>138±41.24</td>
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<tr>
<td>Intraoperative blood loss</td>
<td>840±480.88</td>
<td>390-2000</td>
<td>818±633.47</td>
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</table>
Discussion

The endoscopic endonasal approach to the sellar region is a recent evolution of the conventional transsphenoidal technique performed with the operating microscope. It is rapidly gaining wide acceptance and it is likely to become the standard procedure [6-8]. However, endoscopic transsphenoidal surgery is challenging due to the narrow surgical field, anatomic variations of the sphenoid sinus and the close proximity to important orbital and intracranial structures. Therefore accurate knowledge of the complex local anatomy and precise topographic orientation is essential for successful endoscopic transsphenoidal surgery, particularly in complex cases or in redo-surgery [9,10]. Although complications from transsphenoidal surgery are rare, major complications can occur, however, resulting in entry into the anterior cranial fossa, the orbit or the cavernous sinus [3,4]. To improve surgical accuracy and to enhance patient safety, a number of image-guided systems have been used. Currently, the most common navigational systems used involve nonmechanically linked frameless systems that use either an electromagnetic field or an infrared light-emitting diode. Regardless of the navigation system used, the use of IGS affords the surgeon an improved intraoperative understanding of the spatial positioning of the disease and normal structures.

The combined use of image guidance and endoscopy is the newest advance in transsphenoidal surgery [8]. Anand and Kacker [11] write that 3D imaging reconstruction greatly improves the accuracy and precision of endoscopic transsphenoidal surgery in complex cases. Heermann et al. [12] insist that image guidance endoscopic transsphenoidal surgery technology also proves helpful for training purposes. Reitnauer et al. [13] concludes that the device facilitates the surgical procedure by providing precise instrument position. Nasseri et al. [14] considers IGS as an extremely effective tool for endoscopic transsphenoidal surgery in comparison with fluoroscopy providing only sagittal imaging. Jagannathan et al. [15] reported that IGS in management of 176 sellar lesions resulted in increased accuracy of the approach, with simultaneous reduction in operative time and preoperative planning. IGS with CT-MR fusion images is also very beneficial in endoscopic pituitary surgery [16].

As for the accuracy of navigation systems, Fried et al. [17] have reported navigational errors of about 2.28mm, whereas Anon [18] reported an error of about 2mm by measurements on cadaver skulls. In an experimental study on 20 cadaver heads, Gong et al. [19] have reported an actual visual accuracy of about 1.53mm. They have demonstrated that endoscopic transsphenoidal surgery with IGS possesses a high accuracy at millimetric level and therefore provides precise localization and orientation that helps to achieve better results with lesser risks, particularly in complex cases or in reoperations.

There are numerous favorable reports demonstrating the indications of image guidance in endoscopic transsphenoidal surgery. IGS is especially useful during revision surgery, where normal anatomical structures may be distorted [19,20]. De Lara et al. [21] stated that the presence of sphenoid sinus anomalies, lack of sphenoid pneumatization, lateral pneumatization, or multiple sphenoid sinus septae increases the chances that IGS will be necessary.

Expansive and invasive macroadenomas may obliterate the normal anatomy and even displace the surrounding neurovascular structures. These tumors may expand superiorly to the suprasellar space, laterally to the cavernous sinuses, or inferiorly to the clivus. Information regarding key anatomical landmarks can be provided by IGS and are valuable in order to achieve a safe tumor removal [22]. Patients presenting with tumors closely related to the Internal Carotid Artery (ICA) should routinely be treated with the assistance of IGS, as the technology not only assists in localization in the sagittal plane (to identify the midline), but also allows the surgeon to localize the ICAs and safeguard against inadvertent injury [23]. IGS is also very helpful when addressing suprasellar tumors expanding along the anterior cranial base, when an expanded endonasal transsellar transplanum approach needs to be performed [20].

Limitations related to the use of IGS should be considered. The high cost of the equipment, increased time of surgery due to setup time, and registration and the need of specific training for the operating room personnel could be pointed as limitations of this technology [21].

In the current study, we compared endoscopic transsphenoidal surgery with and without image guidance as regards major complications, operative time and intraoperative blood loss. Regarding major complications, we experienced 10% major complication rate in the study group compared to 30% in the control group. This suggests that IGS help minimize the complications associated with endoscopic transsphenoidal surgery. These results match with those of Frank et al. [24] who reported 11.5%
complication rate associated with image-guided endoscopic transphenoidal surgery.

The study group had a mean total operative time of about 12 minutes longer than the control group. Since this value includes the time required to set up, calibrate, and register the IGS before the start of surgery, the actual surgical time is not prolonged but even shortened as evidenced by our study which shows that the actual operative time was less by about 7.5 minutes in the study group than the control group. Furthermore, this value represents a mean; earlier cases took longer when the surgeon and nursing staff became familiar with the system, that additional operating room personnel were learning to use the equipment. Once the surgeon and nursing staff became familiar with the system, that additional operating room time could be reduced [25-27]. Previous studies have reported additional time requirements ranging from 10 to 20 minutes for the setup and operation of image guided systems [28-30].

The mean intraoperative blood loss was higher by about 22mL in the IGS group than the control group and this was found to be statistically not significant.

Conclusion:

The use of an image-guided system for endoscopic transphenoidal surgery can provide the surgeon with accurate information regarding anatomical localization in cases with poor surgical landmarks caused by extensive disease or prior surgery. Therefore IGS may reduce the complications associated with the procedure and allow for a more thorough operation. However, the use of IGS may lead to an increase in operative time, expense and blood loss.

References

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