Image-guided nasal and skull base surgery: a case–control study

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Received 8 January 2013
Accepted 20 July 2013

The Egyptian Journal of Otolaryngology
2013, 29:235–239

Objective

The objective of this study is to evaluate the efficacy of image-guided systems in nasal and skull base surgeries.

Study design

This is a prospective case–control study.

Materials and methods

A total number of 24 patients were included in this study. The relevant preoperative, operative, and postoperative records were collected and analyzed.

Results

The mean total operative time was greater for the image-guided surgery group (130 min; range 95–160 min) than for the control group (119 min; range 85–150 min). However, the mean actual operative time was less for the image-guided surgery group (93 min; range 65–120 min) than the control group (99 min; range 70–130 min). The image-guided surgery group had no major complications. However, the control group had three major complications (25%). The average estimated blood loss was higher for the image-guided surgery group (395 ml; range 130–1100 ml) than the control group (380 ml; range 100–950 ml).

Conclusion

Image-guided system may reduce the complications associated with endoscopic sinus surgery and allow for a more thorough operation.

Keywords:

image guided system, intra-operative blood loss, nasal and skull base surgeries, operative time

Egypt J Otolaryngol 29:235–239

1012-5574

Introduction

Endoscopic sinus surgery (ESS) is one of the frequently performed procedures in otolaryngology [1]. It is considered the treatment of choice for a variety of paranasal sinus disorders refractory to medical therapy. However, it is associated with both intraoperative and postoperative complications including orbital trauma, dural tear resulting in cerebrospinal fluid (CSF) leak, and intracranial injury, bleeding, and death [2,3]. These potential complications are of more concern when advanced disease processes or postoperative changes (revision ESS) distort the normal anatomy. The loss of surgical landmarks and the shift of important structures result in a potentially more hazardous situation [4]. Although a framed stereotaxic system was described by Horsley and Clarke in 1908, it was not until the1980s that surgical navigation systems became important in neurosurgery and otolaryngology [5,6]. Currently, the most common navigational systems used in ESS involve nonmechanically linked frameless systems that use either an electromagnetic field or an infrared light-emitting diode. Irrespective of the navigation system used, it can determine accurately the precise location of key landmarks and critical structures during the course of ESS, thus providing a safer surgery. Our aim was to evaluate the efficacy of image-guided systems in nasal and skull base surgeries.

Materials and methods

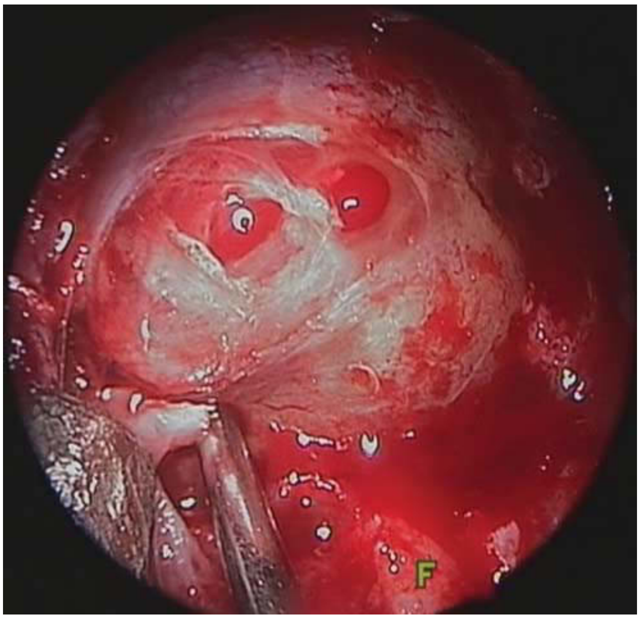
This study was carried out on 24 patients presenting with nasal and skull base pathologies who were treated by endoscopic or extended ESS in the Otorhinolaryngology Department, Faculty of Medicine, Cairo University, during the period between July 2010 and June 2012. All patients were subjected to a preoperative evaluation in the form of careful assessment of history, otorhinolaryngological examination, and radiological investigations. The investigations included computed tomography (CT) of the nose, paranasal sinuses and brain, coronal, axial and/or sagittal cuts, soft tissue, and bone windows (± intravenous contrast); MRI of the nose, paranasal sinuses, and brain was performed in selected patients when delineation of the boundaries of the lesion and their relation to the skull base and orbit needed to be verified. Patients were divided into two groups: the image-guided surgery (IGS) group, which included 12 patients who were operated upon using the navigation system (Kolibri System; Brain LAB, Munich, Germany), and the control group, which included 12 patients who were operated upon without using the navigation system. Both groups were identical in terms of the distribution of the surgical indications.

Operative technique

Either ESS or extended ESS was performed according to the extent and pathology of the lesion as determined by

 DOI: 10.7123/01.EJO.0000433257.24830.f2

Figure 1



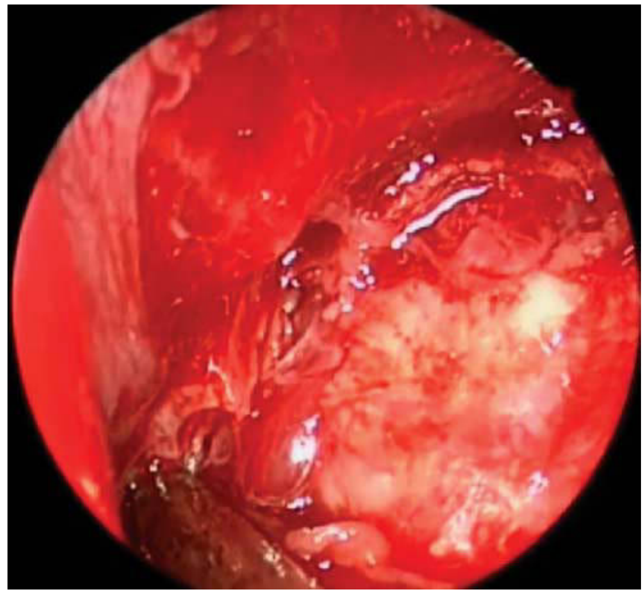
Intraoperative endoscopic view of a case of pituitary adenoma showing the image-guided surgery probe pointing to the adenoma with intact overlying dura.

Figure 2

Image-guided surgery display of the same case of pituitary adenoma.

preoperative CT or MRI. All the procedures were performed under general anesthesia, with the patient in a supine position and the head slightly elevated (anti-Trendelenburg position). All patients in IGS group were operated using an optical-based image-guided system. A headset containing the reflective spheres was placed over the forehead and tightly secured to avoid any shift during the operation. Then, a process of paired-point registration was initiated by defining fiducial points in

Figure 3



Intraoperative endoscopic view of a case of angiofibroma showing the image-guided surgery probe pointing to the tumor.

Figure 4

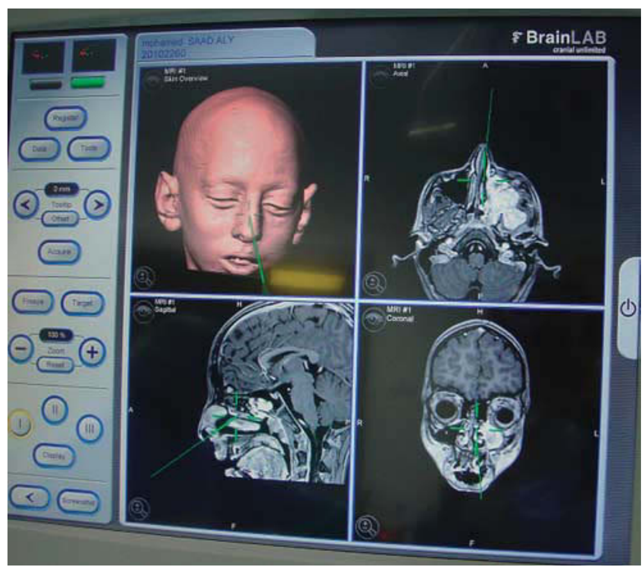
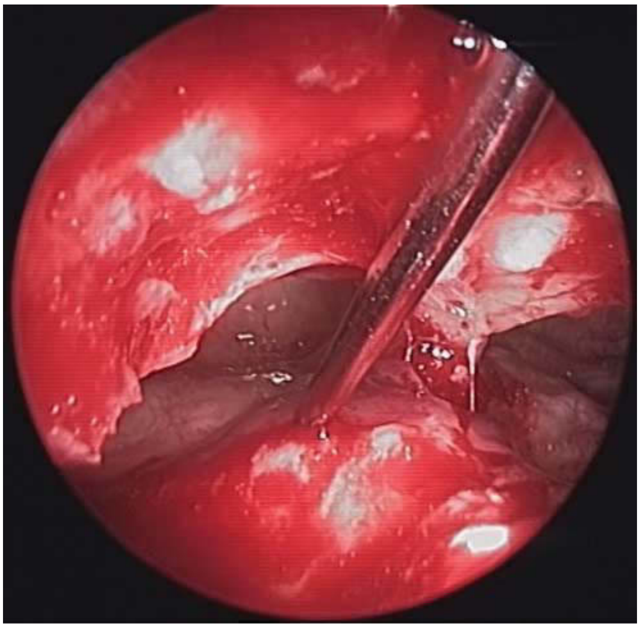


Image-guided surgery display of the same case of angiofibroma.

the imaging data set. Anatomic points (such as the root and tip of the nose, medial, and lateral canthus) were used as fiducial points. Then, the surgeon manually mapped corresponding fiducial points in the operating field volume with a tracked probe. Finally, the computer performed the registration by aligning corresponding points in the preoperative imaging data set and the operative field volume. We used an optical tracking system that included infrared light and a camera tracking system to track variable instrument affixed with reflective spheres, which provided a wireless mechanism for instrument localization that is highly accurate to within

Figure 5



Intraoperative endoscopic view of a case of right frontoethmoidal mucocele for which the Draf 3 procedure was performed showing the image-guided surgery probe.

Figure 6

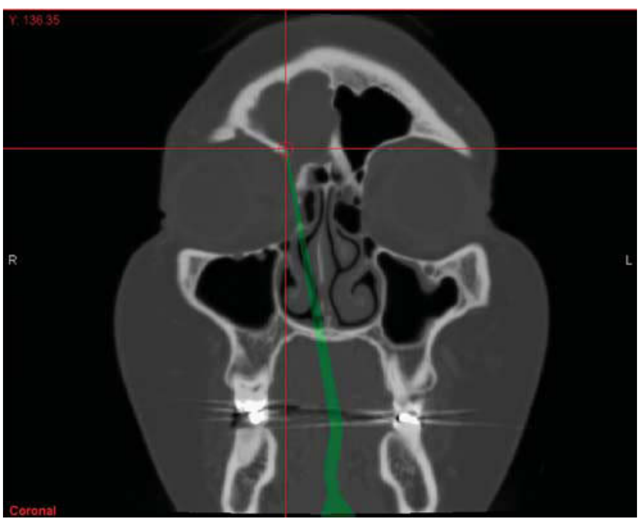


Image-guided surgery display of the same case of right frontoethmoidal mucocele.

2 mm. The computer work station integrates the data set with information from the tracking system and projects the location of the instrument tip simultaneously on all three CT views (coronal, axial, and sagittal) (Figs 1–6).

Outcome parameters

The following parameters were evaluated intraoperatively comparing the two groups of patients: operative time, average blood loss, and intraoperative complications. Time parameters were measured in minutes for two categories: the total time and the actual operative time. The total time is that spent by the patient in the operating room and this reflected anesthesia and surgery times, time for the setup and operation of the image-guided system including placement of the patient head-set, calibration and registration of the handheld probes, and use of the system for anatomical localization throughout the procedure. The actual operative time is the time spent from the start to the end of the surgical procedure. Major complication was described as the occurrence of any one of the following events: intra-operative injury to a major blood vessel with bleeding, postoperative epistaxis requiring blood transfusion or placement of intranasal packs or surgical ligation or embolization, orbital trauma with ocular muscle damage or subjective diplopia, optic nerve injury with decreased visual acuity, dural tear with CSF leak, and intracranial injury with damage to the central nervous system structures.

Statistical analysis

The statistical analysis was carried out using SPSS version 16 for Windows (IBM Corporation, Chicago, USA). Descriptive statistics and frequencies were determined for categorical and numerical variables. The two-sample *t*-test was used for comparative statistical analysis for numerical variables (operative times and intraoperative blood loss). Fisher's exact test was used for comparative statistical analysis for the categorical variable (complications). Statistical significance was set at a *P* value of 0.05 or less.

Results

The IGS group included 12 patients, seven men and five women, mean age of 26 years, range 9–53 years. Surgical indications included pituitary adenoma (two cases), juvenile nasopharyngeal angiofibroma (two cases), CSF rhinorrhea (two cases), pterygopalatine fossa mass (two cases), frontoethmoidal mucocele (one case), frontal sinusitis (one case), optic nerve decompression (one case), and chronic invasive fungal sinusitis (one case). The control group included 12 patients, six men and six women, mean age of 33 years, range 11–60 years. The distribution of surgical indications in the control group was similar to that of the IGS group.

The mean total operative time was greater for the IGS group (130 min) than for the control group (119 min). However, the mean actual operative time was less for the IGS group (93 min) than for the control group (99 min). The mean intraoperative blood loss was higher for the image-guided group (403 ml) than for the control group (380 ml). No statistically significant difference was found between the IGS and the control groups in the total and actual operative times as well as the intraoperative blood loss (Table 1). In terms of the occurrence of major complications, patients in the IGS group did not develop major complications; however, in the control group, three patients developed major complications in the form of dural tear with CSF leak (two cases) and severe

Table 1 Numerical parameters of the image-guided surgery and control groups

	Image-guided surgery group (*n*=12)		Control group (*n*=12)		
Variables	Mean ± SD	Range	Mean ± SD	Range	*P* value
Total operative time	130 ± 19.88	95–160	119 ± 21.40	85–150	0.212 (NS)
Actual operative time	93 ± 17.10	65–120	99 ± 17.94	70–130	0.424 (NS)
Intraoperative blood loss	403 ± 326.88	130–1100	380 ± 269.31	100–950	0.85 (NS)

intraoperative hemorrhage that was controlled by endoscopic cauterization. This was found to be statistically significant ($P = 0.032$).

Discussion

ESS using rigid endoscopes provides only a two-dimensional view, requiring surgeons to localize instruments on the basis of their depth of penetration and tactile sensation. Orientation and localization within the sinonasal tract can be problematic, especially in the setting of extensive disease, revision surgery, or bleeding [7]. Because of the close proximity of intracranial structures and the orbit, complications from sinus surgery, although rare, can be devastating. The use of IGS in revision ESS or complex primary cases provides the surgeon with an improved intraoperative understanding of the spatial positioning of the disease and normal structures. Multiple studies have shown the accuracy of IGS [8–10]. A review of four different image-guided systems by Anon [11] showed an overall accuracy to within 2 mm. The improved anatomic accuracy theoretically decreases the morbidity and improves the efficacy of the procedure.

In this study, we compared ESS with and without image guidance in terms of the operative times, intraoperative blood loss, and occurrence of major complications. In terms of the operative times, the mean total operative time was 11 min longer in the IGS group than the control group; yet, the mean actual operative time was 6 min less in the IGS group. The lengthy total operative time in the IGS group is because it includes the time required to set up, calibrate, and register the image-guided system before the start of the surgery. Once the surgeon and nursing staff became familiar with the system, this additional operating room time can be reduced. Previous studies have reported additional time requirements ranging from 10 to 20 min for the setup and operation of image-guided systems [5,12,13]. No statistically significant difference was observed in the operative times of both groups; this indicates that IGS has no significant influence on the time of surgery. The mean intraoperative blood loss was higher by about 23 ml in the IGS group compared with the control group and again this was found to be statistically not significant.

The use of IGS is associated with a remarkably low complication rate. This is attributed to improved localization of anatomic landmarks as well as reassurance for the surgeon. Tabaee *et al.* [14] studied 85 patients who underwent revision surgery with image-guided system and they reported no serious complication in this group. Loehrl *et al.* [15] reported no complications in their review of 31 patients who underwent IGS for frontal sinus ventilation. In endoscopic pituitary surgery, Jagannathan *et al.* [16] reported that IGS in the management of 176 sellar lesions resulted in increased accuracy of the approach, with a simultaneous reduction in the operative time and preoperative planning. In this study, we encountered no major complications in the IGS group compared with a 25% (three cases) major complication rate in the control group, and this was found to statistically significant. This suggests that IGS helps minimize the complications associated with ESS. These results are in agreement with those of previous studies of complications associated with image-guided ESS. However, the major complication rate in our control group is higher than that of previous reviews (0.3–3%) because of our small sample size.

Conclusion

The use of an image-guided system for ESS can provide the rhinologist with accurate information on anatomical localization in cases with poor surgical landmarks caused by extensive disease or previous surgery. Therefore, IGS is associated with a markedly reduced complication rate and at the same time has no significant influence on the operative time and blood loss. However, we recommend investigating the use of IGS in studies with a larger sample size and a homogenous patient population.

Acknowledgements

Conflicts of interest

There are no conflicts of interest.

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