Available online at http://www.journalijdr.com

ISSN: 2230-9926

IJDR

International Journal of Development Research
Vol. 11, Issue, 11, pp. 51695-51703, November, 2021
https://doi.org/10.37118/ijdr.23034.11.2021

RESEARCH ARTICLE OPEN ACCESS

STUDY OF NAVIGATION ASSISTED FUNCTIONAL ENDOSCOPIC SINUS SURGERY

***Dr. Kamini Chavan, Dr. Nilam U. Sathe, Dr. Swapnal Sawarkar and Dr. Pravin Misal**

Dept of ENT and Head – Neck Surgery, Seth G. S. Medical College and KEM Hospital, Parel, Mumbai - 400 012

ARTICLE INFO

Article History:
Received 20th August, 2021
Received in revised form
19th September, 2021
Accepted 14th October, 2021
Published online 28th November, 2021

Key Words:

Functional Endoscopic Sinus Surgery, Navigation.

***Corresponding author:* Dr. Kamini Chavan**

ABSTRACT

Introduction: Endoscopic sinus surgery(ESS) is the first choice of surgery to treat medicine-refractory sinonasal disease. However, when a single lens system is used to perform ESS, the 2-dimensional imaging results in a loss of depth of field. To lessen complications and operate with greater precision, frameless stereotaxic integration of computed tomography(CT) has been used during functional endoscopic sinus surgery(FESS) for intraoperative real time localization. **Material and Methods:** The present hospital based observational, analytical study was undertaken with 30 patients to evaluate outcome, intraoperative time, intraoperative blood loss and intraoperative complications of navigation assisted functional endoscopic sinus surgery in the Dept. of ENT, at our tertiary care centre. **Conclusion:** Computer aided ESS is one of the best teaching tool for surgeons , it minimizes intraoperative complications by accurate identification of critical landmarks, ensures complete removal of disease which results in successful outcome of surgery.

Citation: ***Dr. Kamini Chavan, Dr. Nilam U. Sathe, Dr. Swapnal Sawarkar and Dr. Pravin Misal.*** "Study of navigation assisted functional endoscopic sinus surgery", *International Journal of Development Research*, 11, (11), 51695-51703.

INTRODUCTION

Chronic sinusitis is an extremely prevalent disorder that has significant impact on quality of life of an affected individual. The terms 'Rhinosinusitis' refers to a group of disorders characterized by inflammation of mucosa of nose and paranasal sinuses. Chronic rhinosinusitis occurs when the duration of symptoms is greater than 12 weeks duration. It is one of the most common problem encountered in ENT practice causing significant morbidity to patients. Any anatomical, physiological or pathological features which in a way or other obstructs free drainage from the sinuses, permits the stasis of secretion and thus predisposes to infection. In most conditions, endoscopic sinus surgery (ESS) is the first choice of surgery to treat medicine-refractory sinonasal disease. It was estimated that over 250,000 procedures were being performed annually in the United States (Bolger). However, when a single lens system is used to perform ESS, the 2-dimensional imaging results in a loss of depth of field. Also, the small visual field limits the learning curve of surgeons. Surgeons may find themselves lost, especially when faced with distorted anatomy, significant disease, significant bleeding, or scarring from previous surgery. This can lead to serious injury to patients, including intracranial penetration and loss of vision. Complications resulting from ESS continue to be one of the greatest sources of litigation facing otolaryngologists today (Bolger). There is an inherent risk of major complications occurring in 0.5–1% of such procedures (May, 1994; Kennedy, 1994). Despite the low occurrence of serious complications, a significant number of severe complications occur every year, given the large number of endoscopic sinus procedures performed. In an attempt to lessen complications and operate with greater precision, frameless stereotaxic integration of computed tomography (CT) has been used by surgeons during functional endoscopic sinus surgery (FESS) for intraoperative localization. Throughout the procedure, the location of the monitored probe can be tracked, allowing surgery on the desired areas while avoiding the surrounding vital structures (Reardon, 2005). This study aimed to evaluate the efficacy of FESS aided by a navigation system.

Early image-guidance systems required fixation of the patient's head in a stereotactic frame during surgery. Subsequently, armless and frameless systems have used either electromagnetic or optical (infrared) signals to localize instruments within the surgical field. This has greatly enhanced the applicability of this technology for FESS, and means less patient discomfort (from headset fixation), and less time and money spent on repeated CT scans. The value of a navigation system lies in its ability to allow the surgeon to accurately determine the boundaries of the surgical field and the location of surrounding vital structures. This facilitates safer and more thorough eradication of disease, particularly in cases of extensive polyposis, revision surgery, and neoplastic sinonasal disease. The navigation system allows more precise and confident identification of specific anatomic sites during FESS. Accuracy to within 2mm is generally acceptable during image-guided surgery. This is useful in confirming the identity of large compartments within the sinus cavities (i.e. posterior ethmoid cell vs. sphenoid), rather than in distinguishing between millimeter increments.[5] image guidance cannot serve as a substitute for a thorough knowledge of the surgical anatomy. The image shown on the navigation system is the same as a CT scan image. The surgeon cannot tell where the blood vessels are from simply looking at the screen. He would be required to make a judgment according to his experience and knowledge of the surgical anatomy. The real-time localization of surgical instruments resulted in safer and more thorough surgery, and setup and operative times can be shortened as the surgeon's technique matures. The navigator system was deemed helpful in situations where the surgical anatomy was altered by previous surgery and extensive inflammatory disease (polyposis, fungal sinusitis, pan sinusitis) (Olson, 2000). Cohen and Kennedy are of the opinion that ESS is no longer exclusively for the management of chronic rhino sinusitis and nasal polyposis.[8]Advances in imaging technology and increased experience with endoscopy has broadened the endoscopic ventral skull base exposure from the odontoid process to the foramen ovale to the olfactory bulb. Sinonasal malignancies as well as anterior skull base lesions have become part of the rhinologist's responsibility (Cohen, 2005). Hence the present study was done at our tertiary care centre to evaluate outcome, intraoperative time, intraoperative blood loss and intraoperative complications of navigation assisted functional endoscopic sinus surgery.

Principles of electromagnetic and optical systems: Electromagnetic and optical localization systems both enable real-time detection of instrument position in a 3Dimentions (3D) imaging repository. At present, such repositories are exclusively based on CT acquisitions reformatted to obtain a series of slices in three dimensions. A software interface matches the imaging repository to a peroperative spatial repository in which the instrument can be located. In electromagnetic systems, the spatial repository is derived from an electromagnetic field including the surgical field, in which the position of an instrument connected up to an electromagnetic support can be determined.

Fig. 1. Optical system of navigation

Matching imaging and spatial repositories initially required fitting the patient with a helmet equipped with magnetic landmarks during preoperative CT scanning and during surgery itself. The helmet is now no longer needed during CT acquisition but only during surgery, the spatial and imaging repositories being matched by surface scanning as in the infrared method. In optical systems, the spatial repository is produced by a battery of two or three infrared cameras which can determine the position of an instrument fitted either with infrared emitters, in what are known as "active" systems (electroluminescent diodes), or with sensors reflecting infrared emitted by a source coupled to the camera, in so-called "passive" systems. Localization uses triangulation from electroluminescent or reflecting landmarks which are fixed with respect to the patient's head (usually by means of a helmet). Matching is based on computerized mathematical analysis of the geometrical concordance between virtual and real anatomic points. This step requires CT images to be processed to obtain a 3D mask of the surface of the patient's face, on which the surgeon can choose virtual landmarks. At the beginning of surgery, a locatable instrument is used to mark the anatomically corresponding real points as precisely as possible ("surface matching"). It is noteworthy that surgery room installation and surgical procedure are unchanged by the use of an electromagnetic system, whereas optical systems require a particular arrangement in the surgery room, avoiding any human or material obstacle between instruments and cameras. The necessary instrument visibility also makes certain demands on surgical procedure. In conclusion, these two systems, with their very different concepts, both enable constant real-time location of coupled instruments on scan images in three dimensions, throughout surgery. Image guidance equipped with an optical system. The spatial repository is acquired from a battery of three infrared cameras which determine the position of an instrument fitted with infrared emitters or infrared-reflecting sensors. Image guidance equipped with an electromagnetic system. The spatial repository is derived from an electromagnetic field including the surgical field, in which the position of an instrument connected up to an electromagnetic support can be determined.

Ideal Criteria for Systems of C-A FESS:

Roth et al (1995) summarized the following criteria for the systems providing image guidance for ESS:

- Accuracy of 2 to 3 mm should be maintained.
- The second CT should be eliminated possibly through standardized surface marking.
- The computer should update for any head movement under general or local anesthesia.
- Sensors should be applied to suctions and dissecting instruments to allow more flexibility.
- The surgeon must easily operate the device in order to eliminate the technicians.

Accuracy: The accuracy of the Surgicom arm, as determined by measurement on a plastic skull and a specially Plexiglas measurement model, is approximately 2.0mm, with 95% of the errors falling between 0 and 3.7 mm (Zinreich *et al*, 1993). Laboratory measurements based on CT scans from a specially constructed phantom show an accuracy of the third-generation mechanical arm of 0.61+- 0.24 mm (mean error+- SD). The accuracy of the optical system is 0.87 +- 0.31 mm. Clinical accuracy of the arm using fiducial markers is 1.8 +- l.l mm. The Flash Point 5000 system has accuracy in the laboratory setting of 1.3 mm. The OptoTrak system has an accuracy of about 2.0 mm in clinical applications. The InstaTrak system has an accuracy of approximately 2.0mm (Anon *et al*., 1997).

Calibration: Calibration is the process by which the navigation system matches the surgeon's reference points on the patient with those on the scan, registered in the navigator. Each point in each volume has specific coordinates, xyz. Calibration aligns the two sets of points. During surgery, the navigation system deduces the position of the operator's instrument by extrapolating the calibration points. Whichever navigation system is being used, there are a few rules to be followed in order to optimize calibration. Points should be relatively fixed and reproducible: mobile points on the face should be avoided, in favor of the tragus, external canthus and nasal root. Calibration systems involving surface scanning of the patient's face need to take account of soft tissue malleability. Clinically, hydration and tension differences in facial tissue between image acquisition when the patient is awake and surgery under general anesthesia can cause significant differences (up to 2 mm) in the position of points. Face contour point selection designs, however, get round this problem by the large number (500–600) of points employed. The surface of the face should be brushed with the instrument held at 90°, avoiding both pressure and loss of contact. Preoperative imaging is thus essential: the scan should be taken with millimetric slices and a

512X512 pixel matrix. Reconstruction should enable facial contours to be defined, and initial CT acquisition should take this into account, including the entire face up to the outer ears.

Fig. 2. Head tracker with tracking probe

Facial surface scanning calibration systems require soft-tissue malleability to be taken into account. The surface of the face should be brushed with the instrument held at 90°, avoiding both pressure and loss of contact. Points should be relatively fixed and reproducible. Thus, mobile points on the face should be avoided, in favor of the tragus, external canthus or nasal root. Each endonasal surgical instrument connected up to the Image guided (IG) system is then calibrated by contact with the reference band.

Instrumentation: The first navigation systems used rectilinear pointers which were hard to manipulate in the nasal fossae. A range of instruments has now been adapted for computer-assisted surgery: straight or angled aspirators, coagulating forceps, rasps, and microdebriders.

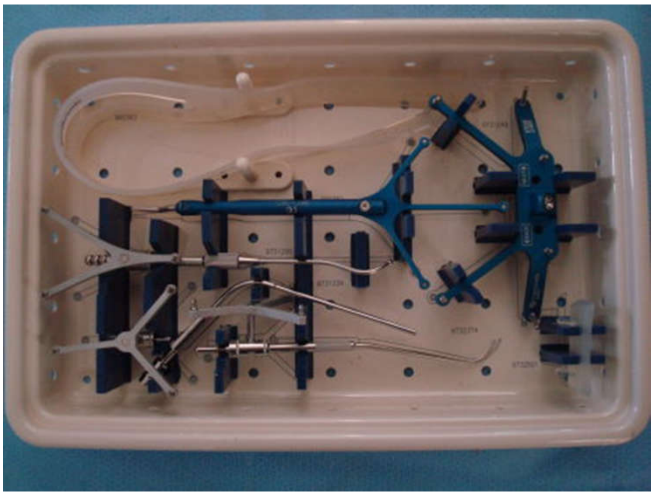


Fig. 3. Navigation Instruments

Role of Image guided surgery (IGS) in sinus surgery: The main contribution of IGS is the possibility of 3D visualization of the sinonasal cavities, compared to the 2D view of endoscopy. The 3D information provided by comparison with the preoperative scans adds depth to the endoscopic images, minimizing localization error. The risk of major complications in endoscopic sinus surgery is low (0–3%), but the potential morbidity and mortality associated with per- and postoperative complications are severe, including blindness, double vision, brain lesion, CSF leakage, epistaxis and death (Maniglia, 1989; Dessi, 1994; Stankiewicz, 1989; Vleming, 1992). Indications for IGS are under debate worldwide, but it is unanimously indicated in sinus surgery neighboring the skull base, the orbit or the optic or carotid nerves. Consensus is emerging for indications in surgery for extensive inflammatory disease, sinus cavity revision, frontal sinus, posterior ethmoid and sphenoid surgery, sinonasal tumor surgery and in sinus surgery with associated congenital facial deformity or post-traumatic facial bone remodeling (Olson, 2000; Tabaee, 2003; Smith, 2007).

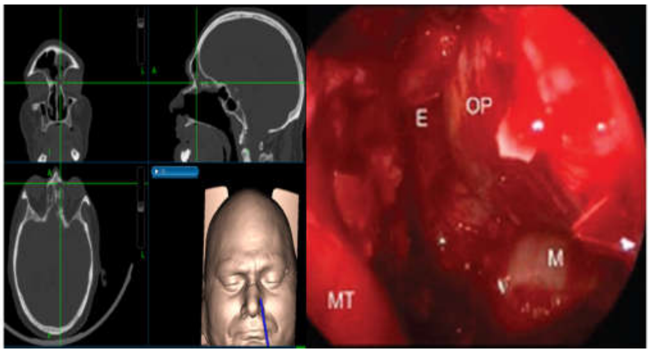


Fig. 4. Dehiscent lamina papyracea in revesion surgery of esthesioneuroblastoma, (MT) middle terbinate, (OP) orbital periosteum, (M) maxilla, (E) ethmoid

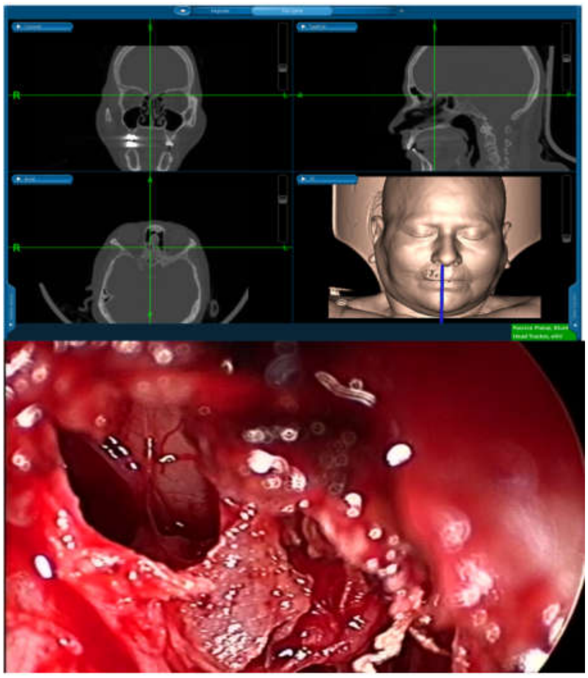


Fig. 5. Navigation assisted identification of csf leak site over medial lamina of cribriform plate

MATERIALS AND METHODS

A hospital based observational, analytical study was undertaken with 30 patients to evaluate outcome, intraoperative time, intraoperative blood loss and intraoperative complications of navigation assisted functional endoscopic sinus surgery.

Study Design: An Observational analytical study.

Study Setting: The present hospital based observational, analytical study was undertaken with 30 patients to evaluate outcome, intraoperative time, intraoperative blood loss and intraoperative complications of navigation assisted functional endoscopic sinus surgery in the Dept. of ENT, at our tertiary care centre.

Duration of Study: 1 year from June 2016 to December 2017.

Study Population: 30 Patients presenting to ENT OPD in the age group of 12-80 years with complaints of nasal blockage, nasal discharge, recurrent rhinitis and epistaxis, reappearance of symptom following FESS surgery, post traumatic loss of vision due to compressed optic nerve, watery rhinorrhea, propotosis.

Sample Size: 30 Patients.

Sample size was calculated using the formula:

n= [z2p(1-p)]/d2

Where: Z = table value of alpha error from Standard Normal Distribution table (1.96)

Power (p) = 80%
Precision error of estimation (d) = 0.07
n= [1.96 x 1.96 x 0.8 (0.2)] / 0.7 x 0.7 = 29.46
Hence the sample size taken for the study was 30. 62

METHODOLOGY

The present hospital based observational, analytical study of 30 patients in the age group of 12-80 years that was done at our tertiary care centre for a period of one year. The subjects for this study consisted of patients presenting to the ENT OPD with complaints of

- Nasal blockage / obstruction (Yes/No)
- Nasal discharge (Mucoid / Mucopurulent /purulent) (Yes/No)
- Epistaxis / bleeding from nose – mild/ moderate/ severe (Yes/No)
- Recurrent rhinitis (Yes/No)
- Anosmia – loss / decrease / change in sense of smell (Yes/No)
- Headache (Yes/No)
- Post nasal drip (Yes/No)
- Watery rhinorrhea (Yes/No)
- Orbital swelling (Yes/No)
- Post traumatic visual complaint (Yes/No)

A thorough and detailed history and examination of nose and paranasal sinuses were performed in all patients preoperatively. The patient undergoing CT PNS Plan + contrast 0.8 mm cut imaging using a set protocol that allows the acquired data to be transferred to a computer workstation of navigation. Axial, coronal, and sagittal views of the location of the monitored instrument's tip are then displayed on the computer screen. Throughout the procedure, the location of the monitored probe can be tracked, allowing surgery on the desired areas while avoiding the surrounding vital structures. The present study aimed to evaluate the efficacy of FESS aided by a navigation system measure in terms of:

- Intraoperative time require for surgery
- Intraoperative blood loss
- Intraoperative complication of surgery
- Outcome of surgery

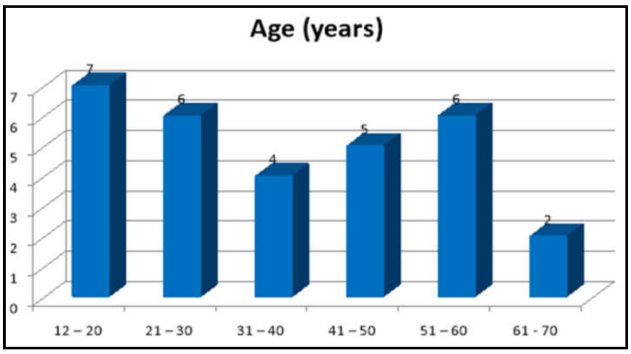
Before surgery, a standardized computer assisted surgery(CAS) sinus CT scan (1 mm axial image) was obtained and transferred to the CAS workstation, where coronal and sagittal images, in addition to 3D-model reconstructions and a software based CT review was completed. After induction of general anesthesia, a headset that permitted attachment of a reference frame, with light emitting diodes for optical tracking, was placed securely on the patient's head and registration and calibration was performed. All patients underwent endoscopic ethmoidectomy, endoscopic maxillary antrostomy, endoscopic sphenoidectomy, and endoscopic frontal recess exposure with frontal sinus suction clearance. The CAS probes were used frequently for confirmation of the surgical tool position. Usually we kept most of the patients in the hospital for one or two days, with discharge, and followed up after one week, when endoscopic debridement was performed. Patients were then followed up every two weeks until the healing process was complete, and then every two months with local treatment. The various parameters compared descriptively between the two groups of patients included, patient demographics, surgical details, operative times, the incidence of complications, and the outcome.

CT scaning protocol: Patients are positioned prone with head hyperextended on the scanner bed. For optimal visualization of the osteometal channels, the field of view should focus only on nasal cavity and paranasal sinuses. Gantry angle should be perpendicular to the bony palate. Slice thickness should be 3 mm table incrementation, 125 kVp, 40 mAs. Scanner computation algorithms are selected to favour the demonstration of the fine air channels and fine bony detail surrounded by mucosa. It is proposed that window widths be set at 2,000 and the window centered at -200. Based on the individual bone thickness and extended soft tissue disease, the potentiometers may be varied for the optimal display of the osteomeatal channels. Scanner "raw" data are transiently saved so that high-resolution bone-enhancing reconstruction can be applied when bone erosion is visualized or suspected. When patients are unable to assume the prone position, axial scans from the palate through the frontal sinus are obtained and indirect coronal reconstructions are generated Stammberger recommends the following parameter. Imaging should be in the coronal plane perpendicular to infra-orbito-meatal line. Slice thickness should be set at 4 mm and when extra detail is required at 2 mm. When no sagittal or axial reconstruction is contemplated, contiguous 4 mm thickness scans should be taken. When reconstruction is planned, thinner or overlapping slices should be chosen. The position of the patient should be prone with head hyperextended. The scan time should be 5 to 7 seconds, window width of +1500 to 2000 HU centered at a level of -150 HU.

RESULTS AND ANALYSIS

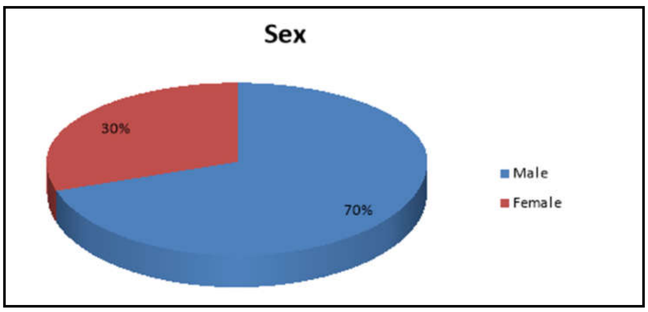
A hospital based observational, analytical study was undertaken with 30 patients to evaluate outcome, intraoperative time, intraoperative blood loss and intraoperative complications of navigation assisted functional endoscopic sinus surgery. The following observations were noted:

Distribution of patients according to Age: Majority of the patients (23.3%) were in the age group of 12-20 years followed by 20% in the age groups of 21-30 years and 51-60 years, 16.7% in the age group of 41-50 years, 13.3% in the age group of 31-40 years and 6.7% in the age group of 61-70 years. The mean age of patients was 37.2±17.18 years.



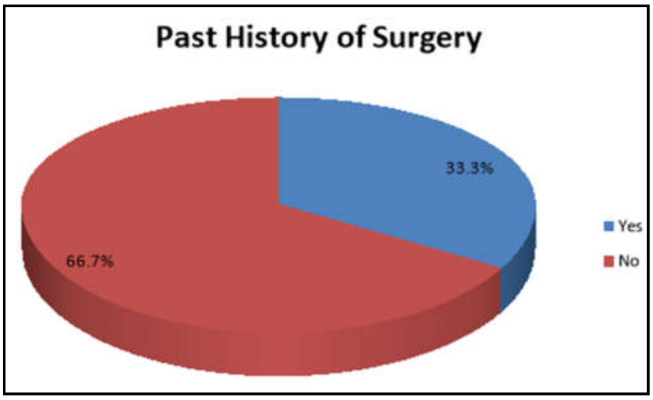
Graph 1. Distribution of patients according to Age

Distribution of patients according to Sex: 70% patients were males whereas female patients constituted 30% of the study population.



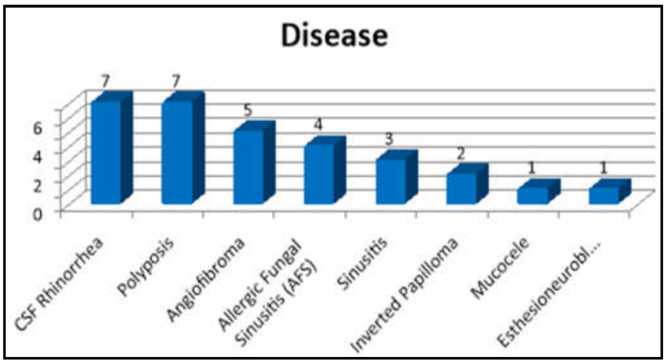
Graph 2. Distribution of patients according to Sex

Distribution of patients according to Past History of Surgery: 10 (33.3%) patients had past history of surgery while 20 (66.7%) patients had no past history of surgery.



Graph 3. Distribution of patients according to Past History of Surgery

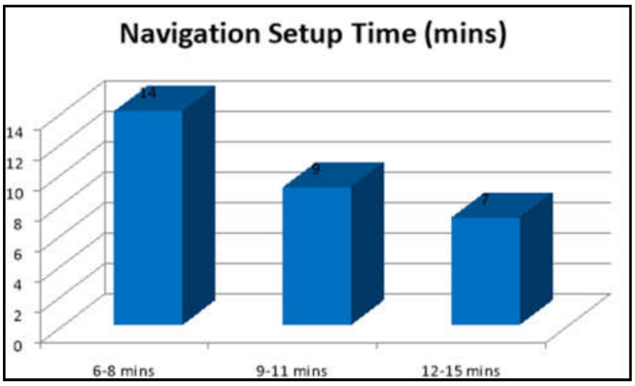
Distribution of patients according to Disease: The most common diseases were CSF Rhinorrhea (23.3%) and Polyposis (23.3%) followed by Angiofibroma (16.8%), Allergic Fungal Sinusitis (13.3%), Sinusitis (10%), Inverted Papilloma (6.7%), Mucocele (3.3%) and Esthesioneuroblastoma (3.3%).



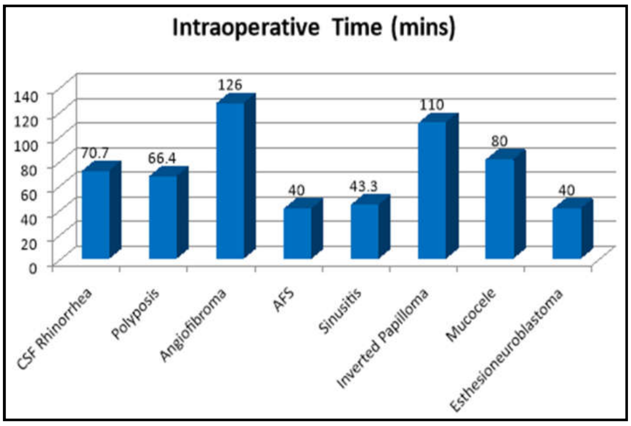
Graph 4. Distribution of patients according to Disease

Distribution of patients according to Navigation Setup Time: The navigation setup time for 14 (46.7%) patients was 6-8 mins while it was 9-11 mins and 12-15 mins for 9 (30%) and 7 (23.3%) patients respectively. The mean navigation setup time was 9.67±2.45 mins.

Association of Intraoperative Time with Disease of patients: The mean intraoperative time for Angiofibroma cases (126.0±25.09 mins) and Inverted Papilloma cases (110.0±56.57 mins) was significantly higher whereas the mean intraoperative time for AFS cases (40.0±8.16 mins), Sinusitis cases (43.3±15.28 mins) and Esthesioneuroblastoma case (40.0±0.1 mins) was significantly lower. The mean intra operative time for all cases was 71.0±34.75 mins.

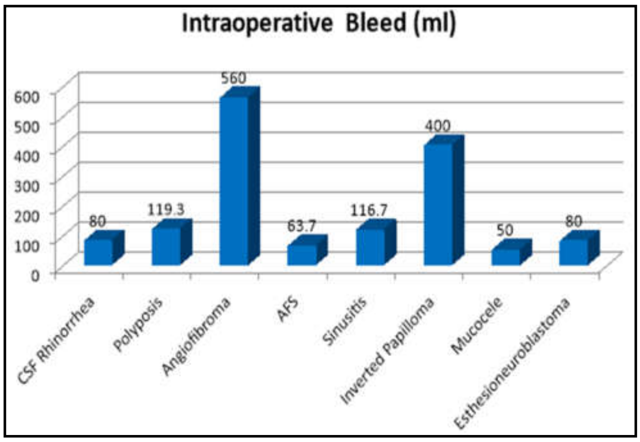


Graph 5. Distribution of patients according to Navigation Setup Time



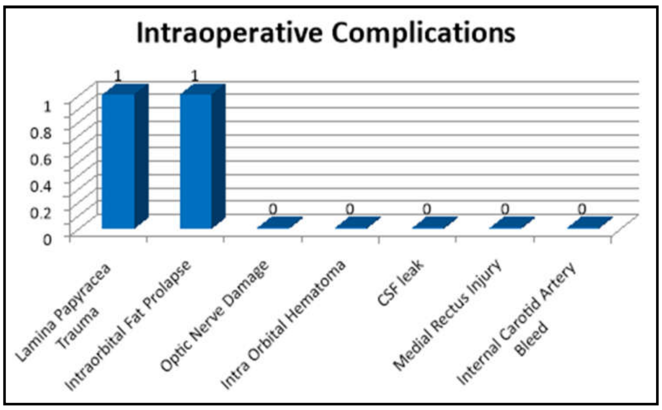
Graph 6. Association of Intraoperative Time with Disease of patients

Association of Intraoperative Bleed with Disease of patients: The mean intraoperative bleed for Angiofibroma cases (560.0±194.94 ml) and Inverted Papilloma cases (400.0±141.42 ml) was significantly higher whereas the mean intraoperative bleed for Allergic fungal sinusitis(AFS)cases (63.7±17.97 ml) and Mucocele (50.0±0.1 ml) was significantly lower. The mean intraoperative bleed for all cases was 182.67±204.79 ml.



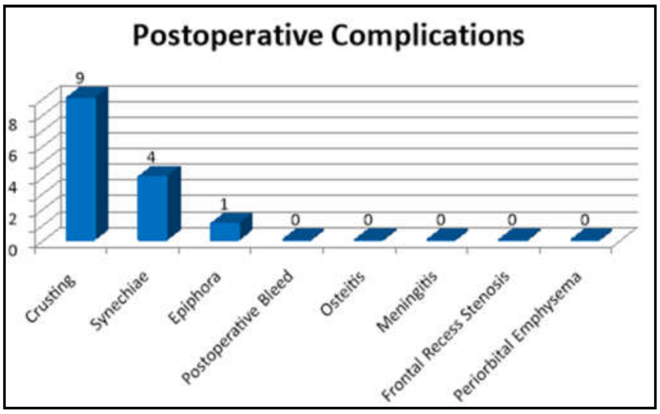
Graph 7. Association of Intraoperative Bleed with Disease of patients

Distribution of patients according to Intraoperative Complications: The intraoperative complication observed in our study was Lamina Papyracea Trauma (3.3%) and Intraorbital Fat Prolapse (3.3%). There were no intraoperative complications such as Optic Nerve Damage, Intra Orbital Hematoma, CSF leak, Medial Rectus Injury or Internal Carotid Artery Bleed.



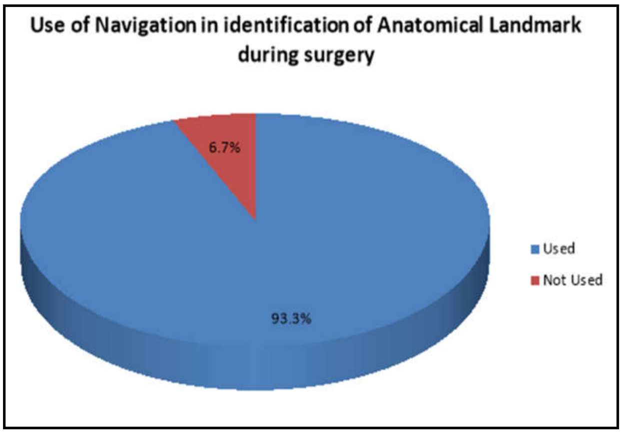
Graph 8. Distribution of patients according to Intraoperative Complications

Distribution of patients according to Postoperative Complications: The postoperative complication observed in our study was Crusting (30%), Synechiae (13.3%) and Epiphora (3.3%). There were no postoperative complications such as Postoperative Bleed, Osteitis, Meningitis, Frontal Recess Stenosis or Periorbital Emphysema.



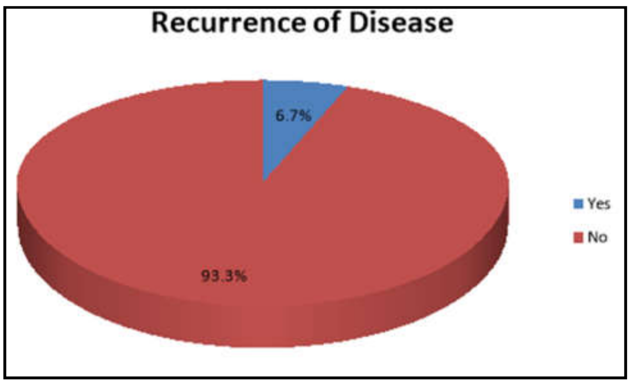
Graph 9. Distribution of patients according to Postoperative Complications

Distribution of patients according to use of Navigation in identification of Anatomical Landmark during surgery: Navigation was used in 28 (93.3%) cases and was not used in 2 (6.7%) cases due to handling error.



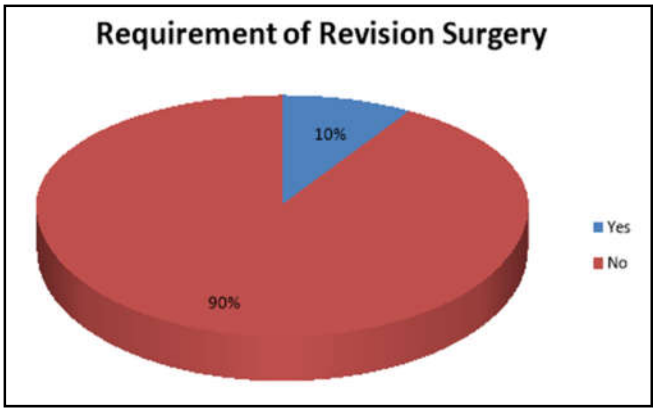
Graph 10. Distribution of patients according to use of Navigation in identification of Anatomical Landmark during surgery

Distribution of patients according to Recurrence of Disease: There were 2 (6.7%) cases of recurrence of disease in operated patients.



Graph 11. Distribution of patients according to Recurrence of Disease

Distribution of patients according to Requirement of Revision Surgery: There were 3 (10%) patients that required revision surgery. 1 patient had developed Epiphora as postoperative complication and required Dacrocystorhinostomy (DCR) surgery while 2 patients developed recurrence of disease.



Graph 12. Distribution of patients according to Requirement of Revision Surgery

DISCUSSION

A hospital based observational, analytical study was undertaken with 30 patients to evaluate outcome, intraoperative time, intraoperative blood loss and intraoperative complications of navigation assisted functional endoscopic sinus surgery. Otorhinolaryngologic surgery in the region near the skull base must be safe and thorough. Most complications occur if the surgeon is not aware of the exact position of his instrument. On account of that, interest in the use of image guidance systems in otolaryngology increased with the development of ESS (Uddin, 2003; Hepworth, 2006). At present, electromagnetic and optical systems are the most widely used because of their acceptable accuracy to within 2 mm or less, the freedom of head movement, and the ability to track a variety of instruments (Anon, 1998; Fried, 1997; Hepworth, 2006; Klimek, 1998; Bradley, 2000). The indications for use of the navigation system are usually extensive disease or previous surgery with poor anatomic landmarks (Chiu, 2004). The navigation system is used to reduce complication rates, complete removal of the disease, and comparatively get fast recovery after surgery. CAS is most helpful in specific anatomic areas, especially in the frontal sinus[25] the sphenoid and the sphenoethmoid regions, the residual ethmoid partition and disease, in skull base identification, and in orbital dehiscence or orbital surgery for optic nerve or orbital decompression (Olson, 2000; Uddin, 2003; Neumann, 1999).

Successful ESS requires a thorough knowledge of the anatomy, in particular the relationship of the nose and sinuses to adjacent vulnerable structures such as the orbit or base of skull. Indeed, major surgical risks in ESS include partial loss of vision or blindness, diplopia, damage to the cribriform plate or to the roof of the ethmoid sinuses, and injury to the internal carotid artery in the wall of the sphenoid sinus (Olson, 2000). Three dimensional image guided navigation system (IGNS) is increasingly acknowledged as a useful technology for ESS (Olson, 2000). In the present study, majority of the patients (23.3%) were in the age group of 12-20 years followed by 20% in the age groups of 21-30 years and 51-60 years, 16.7% in the age group of 41-50 years, 13.3% in the age group of 31-40 years and 6.7% in the age group of 61-70 years. The mean age of patients was 37.2±17.18 years. 70% patients were males whereas female patients constituted 30% of the study population. The average age of males and female patients was comparable. The difference between the groups was statistically not significant as per Student t-test ($p>0.05$). Al-Swiahb JN et al[28] retrospective comparative study evaluating the usefulness of CT-guided endscopic sinus surgery and its advantages over conventional endscopic sinus surgery found 38 males (63.3%) and 22 females (36.7%), with a mean age of 28.2 years (range 11-63 years). Eliashar R et al. (2003) study on computer aided ESS in potentially complex cases and assess the advantages and disadvantages of IGNS found age of the patients ranged from 21 to 67 years (mean 46). Mueller et al. (2010) study on comparing the complication rates and outcome of computer-assisted versus non-computer-assisted functional endoscopic sinus surgery found in both groups, there was a predominance of men: the computer-assisted surgery group comprised 69 (63.9 per cent) males and 39 (36.1 per cent) females, and the non-computer-assisted group 109 (64.9 per cent) males and 59 (35.1 per cent) females. Mean age at the time of surgery was significantly higher in the computer-assisted group, at 48.4 years (range 17.6–82.1 years), than in the non-computer-assisted group, at 42.3 years (range 16.3–83.5 years) (p ¼ 0.0007). In our study, 10 (33.3%) patients had past history of surgery while 20 (66.7%) patients had no past history of surgery. Al-Swiahb JN et al[28] retrospective comparative study reported Surgery was primary in 37 patients (61.7%), and revision in 23 patients (38.3%). The most common diseases in our study were CSF Rhinorrhea (23.3%) and Polyposis (23.3%) followed by Angiofibroma (16.8%), Allergic Fungal Sinusitis (13.3%), Sinusitis (10%), Inverted Papilloma (6.7%), Mucocele (3.3%) and Esthesioneuroblastoma (3.3%). Al-Swiahb JN et al[28] retrospective comparative study evaluating the usefulness of CT-guided endoscopic sinus surgery and its advantages over conventional endoscopic sinus surgery found clinical characteristics of patients in both groups were almost similar, with most of the patients presenting with nasal obstruction and nasal discharge hyposmia. Six (20%) in the computer assisted surgery(CAS)group had proptosis and one had diplopia; in the non-CAS group, seven (23.3%) had proptosis. Additional comorbidities included allergic rhinitis in 54 patients (90%), nasoseptal deviation in 38 (63.3%), and bronchial asthma in 20 (33.3%). Eliashar et al. (2003) study on computer aided EES in potentially complex cases and assess the advantages and disadvantages of IGNS found Seventy four patients (56%) underwent functional EES for chronic sinusitis, 31 (24%) nasal polypectomy, 10 (8%) excision of a mucocele, and 16 (12%) surgery for fungal sinusitis.

Mueller SA et al. (2010) study on comparing the complication rates and outcome of computer-assisted versus non-computer-assisted functional endoscopic sinus surgery reported Chronic rhinosinusitis in 129 patients and nasal polyps in 147 (53.3 per cent). Asthma was present in 70 patients (25.4 per cent) and allergic rhinitis in 58 (21.0 per cent). Other frequent comorbidities included deformation of the nasal septum (n ¼ 47; 17.0 per cent) and mucocele (16; 5.8 per cent). The incidence of these comorbidities was similar in both groups. It was observed in our study that maximum cases of Angiofibroma (13.3%) and AFS (10%) were in the age group of 12-20 years and 21-30 years respectively. There was no significant association of age with disease of patients (p=0.954). Maximum cases of CSF Rhinorrhea (13.3%) were observed in female patients while maximum cases of Polyposis (20%) and Angiofibroma (13.3%) were observed in male patients. There was no significant association of sex with disease of patients (p=0.442). In the present study, the mean intraoperative time for Angiofibroma cases (126.0±25.09 mins) and Inverted Papilloma cases (110.0±56.57 mins) was significantly higher whereas the mean intraoperative time for AFS cases (40.0±8.16 mins), Sinusitis cases (43.3±15.28 mins) and Esthesioneuroblastoma case (40.0±0.1 mins) was significantly lower.

The mean intra operative time for all cases was 1 hour 11 minutes (71.0±34.75 mins). Al-Swiahb et al. (2010) retrospective comparative study reported mean time of surgery was 3 hours and 26 minutes in the CAS group and 3 hours and 13 minutes in the non-CAS group. It was observed in our study that the navigation setup time for 14 (46.7%) patients was 6-8 mins while it was 9-11 mins and 12-15 mins for 9 (30%) and 7 (23.3%) patients respectively. The mean navigation setup time was 9.67±2.45 mins. In our experience, as compared to initial cases the navigation set up time was reduced to less than 10 mins at the end of study. Sau-Tung C[31] study on evaluating the efficacy of FESS aided by a navigation system reported Mean preoperative setup time and mean operative time were 10.6 minutes and 112.3 minutes, respectively. The mean number of paranasal sinuses operated on was 5.8. The mean accuracy of the navigator system was 1.08 mm. In the present study, the mean intraoperative bleed for Angiofibroma cases (560.0±194.94 ml) and Inverted Papilloma cases (400.0±141.42 ml) was significantly higher whereas the mean intraoperative bleed for AFS cases (63.7±17.97 ml) and Mucocele (50.0±0.1 ml) was significantly lower. The mean intraoperative bleed for all cases was 182.67±204.79 ml.

The intraoperative complications observed in our study were minor and few - Lamina Papyracea Trauma (3.3%) and Intraorbital Fat Prolapse (3.3%). There were no major intraoperative complications such as Optic Nerve Damage, Intra Orbital Hematoma, CSF leak, Medial Rectus Injury or Internal Carotid Artery Bleed. Sau-Tung C[31] study on evaluating the efficacy of FESS aided by a navigation system reported Mean blood loss was 102.5 mL. Moreover, operative time, amount of blood loss during the operation, and number of operated paranasal sinuses presented positive associations and significant differences ($p < 0.05$). No major complications such as blindness or cerebral spinal fluid leakage were noted. The postoperative complication observed in our study was Crusting (30%), Synechiae (13.3%) and Epiphora (3.3%). The management of post-operative nasal crusting was done during follow up with nasal clearing of crust whereas synechiae required adhesiolysis which is a minor procedure. There were no major postoperative complications such as Postoperative Bleed, Osteitis, Meningitis, Frontal Recess Stenosis or Periorbital Emphysema. Al-Swiahb et al. (2010) retrospective comparative study reported incidence of postoperative complications was similar for both the groups. Two patients in each group had secondary bleeding; one was treated conservatively and other had to be controlled under general anesthesia. Two patients developed adhesions that were released under local anesthesia. Three patients from the CAS group reported persistent headache in the first postoperative week, which resolved completely with analgesics.

Eliashar et al. (2003) study on computer aided EES in potentially complex cases and assess the advantages and disadvantages of IGNS reported three minor complications that resolved spontaneously: two patients developed a preseptal haematoma and one patient developed periorbital subcutaneous emphysema. Mueller et al. (2010) study on comparing the complication rates and outcome of computer-assisted versus non-computer-assisted functional endoscopic sinus surgery reported in the computer-assisted surgery group, seven patients (6.5 per cent) suffered complications, of which three (2.7 per cent) were considered major and four (3.7 per cent) minor. In the non-computer-assisted group, 10 patients (6.0 per cent) suffered complications, three (1.8 per cent) major and seven (4.2 per cent) minor. No significant difference in complication rates was found between the two groups, with p =0.68 for major complications and p= 1.00 for minor complications and for all complications. Notably, major and minor orbital complications and skull base injuries were only observed in the non-computer assisted group. In the computer-assisted group, two instances of major bleeding occurred: the anterior ethmoidal artery was affected in one case, while the origin of bleeding could not be clearly identified in the other. In our study, navigation was used in 28 (93.3%) cases and was not used in 2 (6.7%) cases due to handling error, most commonly due to non-alignment between optical camera and head frame, faulty registration, gross head movement of head after successful registration leading to poor accuracy while navigation, covering of probe infrared reflector by surgeons hand while manipulation leading to loss of signal or poor signal. Eliashar et al. (2003) study on computer aided EES in potentially complex cases and assess the advantages and disadvantages of IGNS reported In 32 out of 34 cases (94%) the IGNS provided accurate anatomical localisation with less than 2 mm localization error (1.1–2.0 mm, mean 1.6 mm). Localisation errors of 2.2 mm and 2.3 mm were achieved in two patients. In all cases the surgical team felt that the system provided increased intraoperative safety for the patient by assisting in navigating through diseased or surgically revised complex anatomy (mean satisfaction level 3.94). There were 2 (6.7%) cases of recurrence of disease in operated patients in our study which required revision surgery. Al-Swiahb JN et al[28] retrospective comparative study reported higher recurrence rate was seen in the non-CAS group (11 patients, 36.7%) compared to the CAS group (five patients, 16.7%) in the postoperative period ranging from one to two years.

Sau-Tung C[31] study on evaluating the efficacy of FESS aided by a navigation system reported Recurrence in 6 patients (7.59%). In the present study, there were 3 (10%) patients that required revision surgery. 1 patient had developed Epiphora as postoperative complication and required DCR surgery while 2 patients developed recurrence of disease which got managed with revision sugery. Al-Swiahb JN et al[28] retrospective comparative study reported Five patients (16.7%) from the non-CAS group needed revision surgery compared to two patients (6.8%) from the CAS group. Mueller SA et al[30] study on comparing the complication rates and outcome of computer-assisted versus non-computer-assisted functional endoscopic sinus surgery reported Revision in 10 (9.2 per cent) patients in the computer-assisted group and 18 (10.7 per cent) in the non-computer-assisted group (p ¼ 0.84). Cohen NA et al[7] are of the opinion that ESS is no longer exclusively for the management of chronic rhinosinusitis and nasal polyposis.12 Advances in imaging technology and increased experience with endoscopy has broadened the endoscopic ventral skull base exposure from the odontoid process to the foramen ovale to the olfactory bulb. Sinonasal malignancies as well as anterior skull base lesions have become part of the rhinologist's responsibility. The navigation system is used to assist in skull base surgery, and to be very useful in identifying specific locations in a 3-dimensional manner and in helping the surgeon to eradicate the disease.

Summary

- The characteristics of FESS aided by a navigation system include: (1) being able to pilot the relative positions of the operative instruments correctly in 3 dimensions; (2) being able to remove lesions more thoroughly; and (3) its ability to disclose the positions of vessels.
- Computer aided ESS appears to be a useful tool. Nevertheless, the endoscopic surgeon must have a thorough knowledge of the basic anatomy of the nose, sinuses, and anterior skull base, as well as of the various surgical techniques. Computer aided ESS should not by any means be performed by surgeons who are not familiar with regular ESS. For the experienced endoscopist, computer aided ESS is a valuable tool for complex procedures. The present study we believe that for the experienced endoscopist, computer aided ESS enables a new level of efficiency in ESS.
- Computer aided ESS is definitely one of the best teaching tool for surgeons in teaching phase , it minimizes intraoperative complications by accurate identification of critical landmarks these ensures complete removal of disease which results in successful outcome of surgery.

For students it helps by mean of live tracing of endoscopic anatomy in coordination with CT scan of paranasal sinuses bony frame work leading to easy understanding of complex anatomy of paranasal sinuses in three dimensions.

- In our study we came to the conclusion that it is one of the best teaching tool and objective for successful outcome of ESS for beginners as well as expert surgeons.

Financial Support and Sponsorships: Nil

No conflict of interest

REFERENCES

Al-Swiahb JN and Al Dousary SH. Computer-aided endoscopic sinus surgery: a retrospective comparative study. *Ann Saudi Med.* 2010 Mar-Apr; 30(2): 149–152.

Anon JB, Klimek L, Mosges R, and Zinreich SJ (1997): Com- puter-Assisted Endoscopic Sinus Surgery An international re view. *Otolaryngology Clinics of North America* 30 (3): 389-401

Anon JB. Computer-aided endoscopic sinus surgery. *Laryngoscope,* 108 (1998), pp. 949-961

Bergstrom M, Greitz T. Stereotaxic computed tomography. *Am J Roentgenol,* 127 (1976), pp. 167-170

Bolger W, Kennedy D. Complications of surgery of the paranasal sinuses. In: Eisele D, ed. Complications in Head and Neck Surgery. St. Louis: Mosby Yearbook, 993:458–70.

Bradley SE. Image-guided functional endoscopic sinus surgery. *Curr Opin Otolaryngol Head Neck Surg.*2000; 8:3–6.

Cartellieri M, Vorbeck F. Endoscopic sinus surgery using intraoperative computed tomography imaging for updating a three-dimensional navigation system. Laryngoscope 2000; 110:292–6.

Chiu AG, Vaughan WC. Revision endoscopic frontal sinus surgery with surgical navigation. Otolaryngol Head Neck Surg. 2004; 130:312–8.

Cohen NA, Kennedy DW. Endoscopic sinus surgery: where we are and where we're going. Curr Opin Otolaryngol Head NeckSurg 2005; 13:32–8.

Dessi P, Castro F, Triglia JM, Zanaret M, Cannoni M. Major complications of sinus surgery: a review of 1192 procedures. *J Laryngol Otol,* 108 (1994), pp. 212-215

Eliashar R, Sichel JY, Gross M, Hocwald E, Dano I, Biron A, Ben-Yaacov A, Goldfarb A, Elidan J. Image guided navigation system—a new technology for complex endoscopic endonasal surgery. *Postgrad Med J* 2003; 79:686–690.

Fried M, Kleefield J, Gopal H, Reardon E, Ho B, Kuhn F (1997). Image-guided endoscopic surgery: results of accuracy and performance in a multi-center clinical study using an electromagnetic tracking system. Laryngoscope 107:594-601

Hemmerdinger SA, Jacobs JB, Lebowitz RA. Accuracy and cost analysis of image-guided sinus surgery. *Otolaryngol Clin N Am* 2005; 38:453–60.

Hepworth EJ, Bucknor M, Patel A, Vaughan WC. Nationwide survey on the use of image-guided functional endoscopic sinus surgery. *Otolaryngol Head Neck Surg.* 2006;135:68–73.

Kennedy DW, Shaman P, Han W, Selman H, Deems DA, Lanza DC. Complications of ethmoidectomy: a survey of fellows of the American Academy of Otolaryngology–Head and Neck Surgery. Otolaryng Head Neck Surg 1994; 111:589–99.

Klimek L, Mösges R, Schlöndorff G, Mann W. Development of computer-aided surgery for otorhinolaryngology. Comput Aided Surg. 1998;3:194–201.

Maniglia AJ. Fatal and major complications secondary to nasal and sinus surgery. Laryngoscope, 99 (1989), pp. 276-283

May M, Levine HL, Mester SJ, Schaitkin B. Complications of endoscopic sinus surgery. Analysis of 2108 patients: incidence and prevention. Laryngoscope 1994; 104:1080–3.

Mueller SA, Caversaccio M. Outcome of computer-assisted surgery in patients with chronic rhinosinusitis. *The Journal of Laryngology & Otology.* 2010, 124, 500–504.

Neumann AM, Jr, Pasquale-Niebles K, Bhuta T, Sillers MJ. Image-guided transnasal endoscopic surgery of the paranasal sinuses and anterior skull base. *Am J Rhinol.* 1999;13:449–54.

Olson G, Citardi MJ. Image-guided functional endoscopic sinus surgery. Otolaryngol Head Neck Surg 2000; 123:188–94.

Reardon EJ. The impact of image-guidance systems on sinus surgery. Otolaryng Clin N Am 2005; 38:515–25.

Sau-Tung C. Endoscopic Sinus Surgery Under Navigation System—Analysis Report of 79 Cases. *J Chin Med Assoc.* 2006, Vol 69, No 11.

Scott Brown Otorhinolaryngology Head_&_Neck_Surgery. Stammberger H and Lund VJ. Anatomy of the nose and paranasal sinuses 1315 -1344 7th ed. 2008 Edward Arnold (Publishers) Ltd; 2008

Smith TL, Stewart MG, Orlandi RR, Setzen M, Lanza DC. Indications for image-guided sinus surgery: the current evidence. *Am J Rhinol*, 21 (2007), pp. 80-83

Stankiewicz JA. Complications of endoscopic sinus surgery. *Otolaryngol Clin North Am,* 22 (1989), pp. 749-758

Tabaee A, Kacker A, Kassenoff TL, Anand V. Outcome of computer-assisted sinus surgery: a 5-year study. *Am J Rhinol,* 17 (2003), pp. 291-297

Uddin FJ, Sama A, Jones NS. Three-dimensional computer-aided endoscopic sinus surgery. *J Laryngol Otol.* 2003;117:333–9.

Valvassori GE, Mafee MF. Imaging of the head & neck. Gerog Thieme 1995; 248-329.

Vleming M, Middelweerd RJ, de Vries N. Complications of endoscopic sinus surgery. Arch Otolaryngol Head Neck Surg, 118 (1992), pp. 617-623

Zinreich SJ, Tebo SA, Long DM, Brem H, Mattox DE, Loury ME, et al. Frameless stereotaxic integration of CT imaging data: accuracy and initial applications Radiology, 188 (1993), pp. 735-742

ANNEXURE 1

ABBREVIATIONS

FESS – Functional Endoscopic Sinus Surgery
C- FESS – Computer assisted Functional Endoscopic Sinus Surgery
ESS- Endoscopic Sinus Surgery
CT- Computed Tomography
MR- Magnetic resonance
MRI- Magnetic resonance imaging
MRA-Magnetic resonance angiography
DSA – Digital subtraction angiography
CAS-Computed assisted surgery
PNS- paranasal sinuses
IGS- Image guided surgery
3D-Three Dimensions
2D- Two Dimentions
IV – intravenous
OMU- ostiomeatal unit
kV- kilo Volt
mamp- milliampere
DNE- diagnostic nasal endoscopy
CSF- cerebrospinal fluid
ENT –ear nose throat
OPD- outpatient department
cm- centimetre
SER- Spenoethmoidal recess
CRS-Chronic rhino sinusitis
DCR-dacro cystorhinostomy
IGNS-Image guided navigation system
RED-Infra red diaods
SM-maxillary sinus
Inf- maxillary sinus infundibulum
SF- frontal sinus
SN –nasal sepum
S- septum
CI-inferior terbinate
CM-middle terbinate
O- maxilary sinus osteum
MT- middle terbinate

****