Quick Review: Three Dimensional Image Guided Navigation System (Computer Aided Surgery)

Endoscopic endonasal surgery (EES) has become the surgical treatment of choice in many patients who require sinonasal or anterior skull base surgery. Successful EES 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 EES 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.

The development of computer-aided navigation systems (CANS) has added another helpful tool to the operating surgeon's armamentarium. The tip of an instrument can now be localized in real time to a computed tomography (CT) representation on a computer screen in the operating room with reasonable resolution. Although this has not replaced the need for experience and a thorough knowledge of anatomy, the use of image-guided systems for endoscopic sinonasal surgery can help to educate the beginner, give additional information to the experienced surgeon, and prevent orbital and intracranial complications.

The Equipment: This system enables real time surgical navigation using preoperative computed tomographic images and includes a monitor, a computer, an optical camera, a reference head frame, and specialized optical probes. The reference frame and each optical probe contain infrared emitting diodes which transmit infrared light to the optical camera. The camera identifies the location of each source of light and relays this information into the computer. The computer then determines the exact location in space of the tip of the probe. Because the reference frame is attached rigidly to the patient’s head, any movement is detected and the computer compensates mathematically for the deviation.

The Process: Preoperative computed tomography is performed after special fiducial markers are attached to the patient’s face. The data from computed tomography is transferred to the computer in the operating room via the local network.

The computer software restructures the computed tomographic images and displays them on the screen in different perspectives (axial, coronal, sagittal). A three dimensional model of the patient’s anatomy is built.

A "map" relating computed tomographic data to physical points (that is, the patient's anatomy) is derived from a process named "co-registration". After attaching the reference frame to the patient's head, the surgeon selects particular points ("landmarks") from the computed tomography images. He then selects corresponding points from the patient's external anatomy (specific anatomical points around the skull, such as the tragus or fiducials) by means of an optical probe. By analysing the relationship between these points the computer software can build a map, which matches each point in the computed tomography data with its corresponding point on the patient's anatomy.

Intraoperative navigation:

Whenever the surgeon selects a point from the patient's anatomy (for example, the internal carotid artery in the wall of the sphenoid sinus) using the tip of one of the optical probes, the computer uses the above "map" to identify the corresponding point on the computed tomography images. The point is then displayed on the monitor within all the different image planes. The surgeon then knows exactly where the tip of the probe is located in the patient's anatomy and can perform safe surgery. It is important to understand that only preoperative scanning provides the computed tomography data for the operation. This means that tissue changes occurring during surgery do not show on the screen.

Indications: Endoscopic Sinus Surgery, Intranasal procedures, Ear implant procedures, skull base surgery and treatment of skull base tumors with interstitial brachytherapy.

Key Points:

- Malformations, previous operations, and massive polyposis may interfere greatly with intraoperative orientationy during endoscopic sinus surger, thus exposing the patient to major risks.
- CANS using navigations systems is an important aid to surgeons in identifying anatomic landmarks in difficult cases, thus reducing the stress placed on the surgeon and augmenting patients' safety.
- By improving the surgical accuracy, CANS greatly reduces the risk of major intracranial or intraorbital complications
- It also offers a sagittal reconstruction and a three dimensional imaging capacity, which greatly improves the accuracy and precision of EES in complex areas (such as the frontal recess).