ABSTRACT

Objectives/Hypothesis: To evaluate the efficacy of image-guided surgical navigation (IGSN) in otologic surgery and establish practice guidelines.

Study Design: Prospective study.

Methods: Between January 2003 and January 2010, all patients requiring complicated surgery for chronic otitis media, glomus jugulare, atresia, cerebrospinal fluid leak with or without encephalocoele, and cholesterol granuloma of the petrous apex were offered IGSN. The accuracy of IGSN relative to pertinent pathology and 11 anatomic landmarks was established. Additionally IGSN-related operative time, complications, and surgical outcome were recorded.

Results: In the study period there were 820 otologic procedures, of which 94 patients (96 ears) had disease meeting proposed criteria. Thirteen patients (15 procedures) consented to the use of IGSN. All patients had a minimum six months of follow-up. The average additional operative time required was 36.7 minutes. The mean accuracy error was 1.1 mm laterally at the tragus but decreased to 0.8 mm medially at the level of the oval window. The mean accuracy of IGSN was within 1 mm in 10 of the 11 targeted surgical anatomic landmarks.

Conclusions: Interactive image-guided surgical navigation during complex otologic surgery may improve surgical outcome and decrease morbidity by providing an accurate real-time display of surgical instrumentation relative to patient anatomy and pathology. In select cases, the extra cost of imaging immediately prior to surgery and extra operating room time may be compensated by enhancing the ability to distinguish distorted anatomy relative to disease, potentially improving surgical outcome. IGSN, although useful, does not replace surgical expertise and experience.

Introduction

Advances in technology have made significant contributions to improving the practice of medicine and surgery. Image-guided surgical navigation (IGSN) is one example of an application of technology to enhance traditional techniques. The use of these systems can aid in the identification of surgical landmarks, potentially making procedures safer and more efficient. Though there is a long history of stereotactic techniques and image guidance in various surgical specialties, a review of the literature reveals only a modest experience to date in applying these tools to otology or neurotology. Under ideal circumstances, IGSN has the potential for minimizing operative trauma and morbidity with successful eradication of pathology by presenting the surgeon with an accurate anatomic roadmap, distinguishing pathology from surrounding structures at all stages of surgery. The authors postulate that in select otologic procedures, the use of a bone-anchored fixed reference-based navigation system would facilitate surgery and possibly optimize outcome if the accuracy of the system was within 1 mm.

Methods

In a private practice setting over a 7 year period, adult patients with challenging disease matching inclusion criteria were identified and offered IGSN (Table 1). The evening before surgery, each consenting patient had six fiducial markers placed around the surgical ear and three on the contralateral side (Fig 1). The patients underwent high resolution non-contrast computed tomography (CT) with 1.0mm thickness images. Intraoperatively, after general anesthesia, a 1.5cm incision was created and a skull post with an X-shaped reference arc was attached in sterile fashion with a 4mm self-tapping screw, ipsilateral to the surgical ear, just lateral to the sagittal sinus (Fig 2). Registration using the software was completed. Throughout each procedure, accuracy of the probe tip localization at a pertinent operative site was determined in reference to 11 targeted anatomic landmarks (if intact and visualized). Deviations were measured on the workstation computer screen and recorded.

Results

In the study period there were 820 otologic procedures and 94 patients (96 ears) with disease meeting proposed criteria. Thirteen patients (15 procedures) consented to the use of IGSN. All patients had a minimum six months of follow-up. The average additional operative time required was 36.7 minutes for all procedures, and this decreased to 27.6 minutes for the last eight cases. The mean accuracy error was 1.1 mm laterally at the tragus but decreased to 0.8 mm medially at the level of the oval window (Table 2). The mean accuracy of IGSN was within 1 mm in 10 of the 11 targeted surgical anatomic landmarks. In two cases IGSN was not able to be used. In one case the reference post was dislodged early in surgery, and in the other case a malfunction in image data transfer occurred.

Discussion

Early reports in the English literature on IGSN being applied in otolaryngology focused on rhinologic surgery. This study postulated that navigational probe tip accuracy within 1mm would designate IGSN a “useful” adjunct during complex otologic surgery. This criteria was achieved on average in 10 of 11 targeted anatomical landmarks. The navigation system’s view coupled with the surgeon’s view is depicted in a cadaver trial (Fig 3) and intraoperatively (Fig 4). The most frequent objections expressed by potential study patients were: the need for hair shaving and a separate incision site, aversion to the thought of having a metallic post with a screw, the inconvenience and risks associated with additional imaging and most commonly concern regarding the lack of existing documentation that the technology would significantly improve outcomes. At least some of the concerns may be partly addressed by a newer system which no longer requires a separate incision site, additional imaging, or most commonly concern regarding the lack of existing documentation that the technology would significantly improve outcomes. At least some of the concerns may be partly addressed by a newer system which no longer requires a separate incision site, additional imaging, or most commonly concern regarding the lack of existing documentation that the technology would significantly improve outcomes.

Conclusions

Interactive image-guided surgical navigation during complex otologic surgery may improve surgical outcome and decrease morbidity by providing an accurate real-time display of surgical instrumentation relative to patient anatomy and pathology. In select cases, the extra cost of imaging immediately prior to surgery and extra operating room time may be compensated by enhancing the ability to distinguish distorted anatomy relative to disease, potentially improving surgical outcome. IGSN, although useful, does not replace surgical expertise and experience.