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Computed Tomography Image Navigation Patient Tracker on the Cheek During Osteoplastic Flaps

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INTRODUCTION

Despite the widespread success of endoscopic approaches to treat a myriad of frontal sinus pathology, clinical indications such as frontal sinus fractures, neoplasms, encephaloceles, or select cases of recalcitrant frontal sinusitis remain where the frontal sinus must be accessed through a coronal incision and an osteoplastic flap (OPF). One of the more challenging portions of the OPF is determining where to make osteotomies through the anterior tables of the frontal sinuses so that the surgeon does not inadvertently penetrate into the intracranial space and cause a cerebrospinal fluid leak or intracranial hemorrhage. Various techniques have been described to perform these osteotomies safely and reliably during an OPF. The 6-foot penny Caldwell x-ray was classically used to delineate the margins of the frontal sinus when performing an OPF. Transnasal or transfrontal transillumination using various light sources or endoscopes have also been used to illuminate and delineate the frontal sinus borders. Computed tomography (CT) image navigation technology has become extremely precise for anatomic localization during sinonasal and skull base surgery, with decreased major and total complications. CT image navigation is therefore an attractive alternative to using the 6-foot Caldwell and transillumination techniques to localize the frontal sinus borders during an OPF procedure.

Multiple companies sell different types of CT image navigation machines and software. The Fusion ENT Navigation system (Medtronic, Minneapolis, MN), a CT image navigation system commonly used by sinus and skull base surgeons, allows various types of electromagnetic (EM) patient trackers that are usually fixed to the patient’s forehead. One of the newest patient trackers is the AxiEM Noninvasive Patient Tracker (Medtronic), which is a small plastic sticker typically placed along the midline forehead, just superior to the glabella. Placement of the tracker on the forehead is effective during endoscopic sinus and skull base surgery, but it will not work during an OPF when the forehead skin flap is elevated and retracted inferiorly over the face. For these
situations, a cranial dynamic reference frame (DRF) tracker (Medtronic) must be screwed into the skull, but in a position further superiorly, in the parietal area of the skull. In this report, we present the utility of placing the AxiEM patient tracker over the malar prominence of the cheek (zygomatic bone), avoiding the more invasive technique of screwing the cranial DRF patient tracker into the skull, when using CT image navigation during an OPF procedure.

Fig. 2. (A) The Medtronic AxiEM patient tracker is seen on the right cheek on the preverification image navigation screen. (B) Post-verification and calibration image navigation screen demonstrating successful calibration. Lower portion of the screen shows green crosshairs at the nasal tip, representing the superb accuracy of the registration probe that was pressed against the nasal tip as shown in Figure 1. [Color figure can be viewed in the online issue, which is available at www.laryngoscope.com.]
of a grade 4 frontal sinus osteoma, rate. One important case example from our experience was that surgeon’s confidence that the image navigation system is accurate, and the osteotomies have been made over the AxiEM patient tracker, which remains undisturbed from other light source can also be used adjunctively to add to the tracker has been superb, and the osteotomies have been made registration probe and a marking pen (Fig. 4). In our experience, the delineation of the frontal sinus borders during cadaver dissections, and showed that image navigation was the most accurate and least likely to overshoot the frontal sinus margins, and therefore was suggested to be the safest method to use during OPFs.\textsuperscript{10} Melroy et al. also conducted a cadaveric study comparing the same three techniques, and similarly noted that CT image navigation was statistically superior to transillumination and the 6-foot Caldwell in terms of predicting the frontal sinus margins for performing OPF osteotomies.\textsuperscript{11}

The Medtronic Fusion ENT image navigation system relies upon the EM emitter to recognize the EM patient and instrument trackers. The newest AxiEM patient tracker by Medtronic is easy to use and reliable, and by convention is placed along the midline forehead superior to the glabella.\textsuperscript{7} This location will not work during an OPF procedure because the AxiEM patient tracker would be elevated with the scalp flap and rotated over the orbits, altering the spatial location and signal of the EM transmitter. One solution for this critical problem is simply placing the AxiEM patient tracker over another bony prominence of the face, such as the malar prominence of the cheek. The AxiEM patient tracker works best if the three-dimensional spatial location does not change during the course of surgery to avoid changes in anatomic accuracy. This simple method has proven to be as, if not more, effective than our prior use of the Medtronic cranial DRF tracker. In fact, placement of the cranial DRF tracker in the parietal scalp can be problematic for registration and calibration of the system because it is further from the frontal sinuses than the zygomatic bone. Of course, the most glaring benefit of the simple but novel placement of the AxiEM patient tracker over the cheek is the avoidance of the more invasive method of screwing the cranial DRF tracker into the skull, which brings with it a risk of infection and possibly more postoperative pain. Additionally, the surgeon avoids the cost of purchasing a DRF tracker and AxiEM tracker for different surgeries (i.e DRF tracker for osteoplastic flaps and AxiEM tracker for sinus surgery).

**DISCUSSION**

During an OPF procedure, one of the most challenging and stressful parts of the case for the surgeon is delineating the borders of the anterior table of the frontal sinus, and performing the osteotomies based upon the surgeon’s predictions by using one or more of the aforementioned techniques (6-foot Caldwell, transillumination, or image navigation). Whatever technique is used, accuracy is essential. Using image navigation to delineate the frontal sinus borders during OPFs has been shown to be the most accurate of these techniques. An early independent study by Carrau et al. in 1993 demonstrated poor reliability of the 6-foot Caldwell x-ray due to variable factors (i.e., not being exactly 6 feet away, differential penetration of x-rays) and superior technique with “computer [assistance].”\textsuperscript{9} Ansari et al. compared sinus image navigation, 6-foot Caldwell x-ray, and sinus transillumination for delineation of the frontal sinus borders during cadaver dissections, and showed that image navigation was the most accurate and least likely to overshoot the frontal sinus margins, and therefore was suggested to be the safest method to use during OPFs.\textsuperscript{10} Melroy et al. also conducted a cadaveric study comparing the same three techniques, and similarly noted that CT image navigation was statistically superior to transillumination and the 6-foot Caldwell in terms of predicting the frontal sinus margins for performing OPF osteotomies.\textsuperscript{11}
There are also some technical points worth mentioning. First, why choose the cheek to place the AxiEM patient tracker? Medtronic recommends placing the patient tracker over a nonmobile bony surface and near the vicinity of the paranasal sinuses; the malar prominence fits both these criteria. The tracker will not perform optimally if placed further posteriorly on the scalp. The AxiEM patient tracker is designed to operate oriented with the divot directed inferiorly, and we have found that the system calibrates most reliably in this position. This then requires the wire to be directed and secured inferiorly away from the OPF surgical field. One final technical point is in regard to planning and performing the anterior table osteotomies during the OPF. Given that there is up to a 2-mm error with the image navigation system, the surgeon can plan the osteotomies on the inside of the marked frontal sinus border line, about 2 mm off the marked line to be safe.

**CONCLUSION**

When using the Medtronic Fusion ENT image navigation system, placing the new AxiEM patient tracker...
on the malar prominence is effective and reliable when performing an OPF. More specifically, it allows for accurate delineation of the borders of the anterior table of the frontal sinuses when performing an OPF procedure. Surgeons should consider placing the AxiEM patient tracker on the patient’s malar prominence rather than the more invasive skull-mounted Medtronic cranial DRF tracker.

BIBLIOGRAPHY