BACKGROUND: Recent advances in biomedical software allow the conversion of medical imaging into precise three-dimensional (3D) anatomic models. Complex temporal bone anatomy and lateral skull base anatomy represent ideal applications with the potential for surgeons to view and manipulate pre-operative imaging for operative planning when combined with augmented reality (AR) technology. Herein, we describe our approach to creating a high-resolution AR temporal bone.

METHODS: Computed tomography (CT) temporal bone series (0.6mm thickness) in a patient with superior canal dehiscence (SCD) were volume rendered into a 3D model using AMIRA 3D software (Burlington, MA). The temporal bone model was incorporated into a 3D game environment (Unity 3D game engine, San Francisco, CA) and projected onto an augmented reality field using Vuforia software development kit (Needham, MA). Data was uploaded onto a smartphone fitted into Google Cardboard viewer (Mountain View, CA).

RESULTS: Construction of a high-resolution temporal bone model was achieved from pre-operative scans in a patient with SCD. The surgeon enters an AR environment, views the 3D projection of the temporal bone, and has the ability to zoom, rotate, and clip through layers of the temporal bone in all dimensions and with the viewing resolution of a temporal bone CT. As the AR is based on the optical inputs of a smartphone, the model is highly mobile.

CONCLUSIONS: We successfully exported 3D models derived from high-resolution CT temporal bone scans onto smartphone-based augmented reality. This provides a portable tool for skull base surgeons to visualize patient anatomy for pre-operative planning.

WHAT IS AUGMENTED REALITY?

What is Augmented Reality (AR)?
- AR combines real-world environments with computer-generated sounds, text, and graphics

How does AR apply to surgical planning?
- Record advances in biomedical software allow the conversion of medical imaging into precise three-dimensional (3D) models.
- Surgeons can view and manipulate pre-operative imaging for surgical planning when these models are combined with augmented reality (AR).

What is the purpose of this study?
- We describe our approach in developing a high-resolution AR temporal bone.

METHODS

- Computed tomography (CT) temporal bone series (0.6mm thickness) in a patient with superior canal dehiscence (SCD) were volume rendered into a 3D model using 3D Slicer and AMIRA 3D software (Burlington, MA) (Figure 1).
- The 3D temporal bone model was exported onto Unity 3D game engine (San Francisco, CA) and stereoscopically incorporated into an interactive 3D “game environment” (Figure 2).
- The game was converted into augmented reality using Vuforia software development kit (PTC Inc., Needham, MA) (Figure 3).
- Data was exported onto a smartphone and fitted into a virtual reality viewer worn by the user (Figure 4).

RESULTS

Construction of a high-resolution temporal bone model was achieved from pre-operative scans in a patient with superior semicircular canal dehiscence. The surgeon enters an AR environment, views the 3D projection of real temporal bone anatomy, and has the ability to zoom, rotate, and clip through layers of the temporal bone in all dimensions and with the viewing resolution of a temporal bone CT. As the AR is based on the optical inputs of a smartphone, the model is highly mobile.

DISCUSSION

We successfully exported 3D models derived from high-resolution temporal bone scans onto a smartphone-based augmented reality app. Construction of a high-resolution temporal bone model in augmented reality environment was achieved using 3D Slicer model generator, Unity game engine, and Vuforia augmented reality software development kit. All three programs are free and/or open source. Coupled with a mobile device and virtual reality viewer, this application allows the surgeon to enter an AR environment, view the 3D projections of a patient's temporal bone, and has the ability to zoom, rotate, and clip through layers of the temporal bone in all dimensions and with the viewing resolution of a cone-beam temporal bone CT. As the AR is based on the optical inputs of a smartphone, the model is highly mobile. Future applications for AR include diagnosis, medical education, and procedural simulations.