Teaching Frontal Sinus Anatomy Using the Frontal Sinus Masterclass 3- D Conceptualization Model

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Objective: Frontal sinus anatomy is complex and often is a difficult subject to both teach and learn. The traditional surgical dogma of "see one, do one, teach one" is impractical and dangerous in the frontal sinus. Based on the building block three-dimensional conceptualization module, the Frontal Sinus Masterclass (FSMC) was created to teach this anatomy.

Methods: Study was performed at two academic centers among second- to fifth-year otolaryngology residents. A pretest assessed knowledge prior to the course. Computed tomography scans of the sinuses were evaluated in triplanar view, and participants attempted to reconstruct the anatomy. Subsequently, the course instructor explained the anatomy using the building block method and showed a short video of the surgical dissection, pointing out relevant anatomy. Cases progressed in anatomical difficulty and inflammatory load. A posttest determined knowledge after the course.

Results: Thirty of 50 participating residents completed the pre- and posttests (14 junior, 16 senior residents). Correct identification of the frontal sinus drainage pathway increased from 42% to 63% correct ($P = 0.054$). Anatomical assessment increased from 61% to 68% correct ($P = 0.047$), and overall assessment increased from 52% to 66% correct ($P = 0.016$).

Conclusion: Objectively, participants of the FSMC expanded on their ability to recognize cells of the frontal recess on CT scans. Before the class, residents could answer less than half of the answers correctly, and by the end of the class they were answering over two-thirds of these complex questions correctly. Subjectively, participants reported benefit from the course and felt they would be better surgeons.

Key Words: Frontal sinus, 3D conceptualization, surgical education, anatomy, residency.

Level of Evidence: NA.

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INTRODUCTION

Surgical management of inflammatory disease of the frontal sinuses is among the most challenging problems faced by sinus surgeons for multiple reasons. The frontal recess and frontal sinuses are bordered by critical structures, leading to concerns of injury.[1] Additionally, surgery mostly is performed with angled visualization in an anterior and superior location within the nasal cavity, making this area difficult to access. However, potentially one of the biggest hurdles that a surgeon faces is the highly variable and often complex anatomy.[2,3] As a result of all these factors, surgeons may perform incomplete surgery, resulting in a patient's failure to improve or even worsening symptomatology due to stenosis.[4,5] Over time, surgical management of the frontal sinus has changed dramatically,[6] but accurate preoperative planning, knowledge of the anatomy, and meticulous surgical execution all are still critical for successful surgical outcomes in frontal sinus surgery.

Teaching, learning, and mastering these skills all are demanding. Traditional otolaryngology training follows an apprenticeship model.[7] However, this model can be problematic when case difficulty is sporadic or when cases are overly complex for the resident learner.[8,9] In fact, untrained residents yield higher complication rates when performing.[10]

Over the past decade, simulation training has become an increasingly common means of teaching surgical skills. Multiple studies have identified a positive correlation between simulation use and resident confidence and performance[11–15]; however, there is need for a standardized simulation ESS curriculum.[6,16] To date, even the best simulators lack fidelity to fully experience frontal sinus anatomy.

To simplify understanding of frontal sinus anatomy, a three-dimensional (3D) conceptualization module (*building block*) was established to determine the cellular anatomy of the frontal recess and sinus outflow tract using computed tomography (CT) scans.[17–20] Akin to wooden building blocks, a block is generated for each frontal recess cell. Using triplanar CT imaging, the cells are identified,

starting with the agger nasi (AN). Additional cells are subsequently placed in relation to the AN. Finally, the location of the frontal sinus drainage pathway as it passes through the frontal recess is identified.

An educational 3D frontal sinus conceptualization module termed the *Frontal Sinus Masterclass* (FSMC) was developed to teach this complex and variable anatomy utilizing structured sinus CT scan review, followed by viewing corresponding surgical videos of the frontal sinus dissection. The aim of this study is to determine whether participation results in increased objective improvement in knowledge of frontal sinus surgical anatomy in otolaryngology resident trainees.

MATERIALS AND METHODS

Course Design

Computed tomography scans of patients suffering with chronic rhinosinusitis who underwent endoscopic frontal sinus surgery were reviewed. Scans were selected by a single reviewer (P.G.C.) based on varying levels of anatomical complexity, with preference to images with lesser degrees of sinus opacification.

Corresponding surgical videos were reviewed and selected for video quality, surgical field, clear identification of the frontal sinus outflow tract, and stepwise dissection of the frontal recess cells. Deidentified videos were then edited using Final Cut Pro X (Apple Inc, Cupertino, California, U.S.A.) and condensed to approximately 3 to 5 minutes to highlight the frontal sinus dissection. Computed tomography scans and videos were deidentified.

Study Settings and Intervention

The study was conducted among residents from multiple training programs who attended sinus courses at The University of Texas Health San Antonio (San Antonio, Texas, U.S.A.) and McGill University (Montreal, Canada). Institutional review board (IRB) approval was obtained from each center (University of Texas HSC20150382E, and McGill A05-E37-15A). Participation in the study was anonymous and voluntary. Written consent was obtained where required by the IRB.

Inclusion criteria included any second- to fifth-year resident in an accredited otolaryngology training program. Exclusion included medical students, interns (postgraduate year [PGY] 1), nonotolaryngology residents, fellows, physician assistants, nurse practitioners, and surgeons who had completed residency training.

Participants viewed a 15-minute lecture to summarize frontal sinus terminology and explain the use of triplanar (coronal, sagittal, axial) CT imaging to recreate the frontal sinus anatomy using the building block method, as popularized by Wormald.[17,20,21]

On personal computers, participants used the DICOM (Digital Imaging and Communication in Medicine; National Electrical Manufacturers Association; Rosslyn, Virginia, U.S.A.) viewer of their choice. Primarily, Windows users utilized the RadiAnt viewer (Medixant, Poznan, Poland) and Mac users utilized Osirix software (Pixmeo SARL, Bernex, Switzerland). Participants were also given wooden blocks with fabric hook-and-loop fasteners attached to the sides to re-create the anatomy (Fig. 1). Pipe cleaners were used to represent the frontal sinus drainage pathway in relationship to the blocks.

Participants had 8 minutes to reconstruct the anatomy. The course director then reviewed the CT scans and showed the correct building block reconstruction. Finally, participants watched a 3- to 5-minute video of the actual surgical dissection
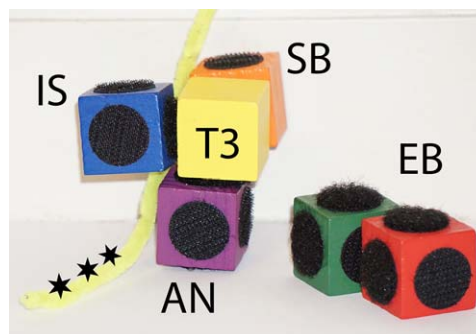

Fig. 1. Blocks which represent each cell of the frontal recess. Each block represents one cell. Pipe cleaner (stars) denote frontal sinus drainage pathway.
AN = agger nasi cell; EB = extra blocks; IS = intersinus cell; SB = suprabullar cell; T3 = type 3 cell. [Color figure can be viewed in the online issue, which is available at www.laryngoscope.com.]

of the obstructive frontal sinus cells, with identification of the frontal sinus drainage pathway.[22]

The anatomy became progressively more complex throughout the course. The participants reviewed eight different sides during the 2.5-hour course. Upon completion, the participants completed a postcourse survey, which included their opinions about the course as well as four additional frontal sinuses to evaluate to evaluate their knowledge.

Survey and Data Collection

Study data were collected and managed using the Health Insurance Portability and Accountability Act of 1996-compliant Research Electronic Data Capture (REDCap) electronic data capture tools hosted at University of Texas Health San Antonio.[23] REDCap is a secure, web-based application designed to support data capture for research studies.

A precourse survey was voluntarily and anonymously completed by the participants, including a self-reported level of experience in frontal sinus surgery, subjective information about their comfort, and objective testing of their ability to interpret frontal sinus anatomy and drainage pathways (Table I). The precourse assessment consisted of identifying the cellular structure and localization of the drainage pathway on four frontal sinuses.

At the course conclusion, an immediate postcourse survey was administered, which queried subjective comfort level and ability to interpret frontal sinus anatomy and drainage pathway after the course, as well as impression of the course. Additionally, four new frontal sinuses were presented to objectively measure changes in knowledge.

Statistical Analysis

Statistical analysis was performed with SPSS 22 (IBM, Armonk, New York, U.S.A.), and Microsoft Excel 2010 (Microsoft, Redmond, WA) was utilized for all figure generation. Anatomical knowledge before and after the intervention was compared using paired t test, and change in subjective knowledge was measured with one sample t test. Nonparametric Spearman's rho was calculated to correlate the ranked ordinal responses collected on surgeon comfort performing frontal surgery, volume of estimated cases performed, and the precourse assessment of frontal anatomy. Surgeon comfort levels between junior and senior level trainees were compared using the Fisher exact test.