Introduction

• Surgical residents learn by watching and performing surgery.
• Septoplasty is a nasal surgery that aims to improve breathing by correcting a deviated septum.
• Septoplasty is performed inside the nose, which makes it difficult for surgical residents to observe proper technique demonstration.
• One of the steps in septoplasty is cutting the septal nasal cartilage, which needs to be performed with extreme precision to minimize post-surgery complications.

The Problem

• A surgical cut of the septal nasal cartilage needs to sufficiently preserve a critical region called L-strut region in the cartilage.
  • Removing more cartilage than necessary may cause collapse of the nose bridge and other complications.
  • Removing less cartilage than necessary can potentially leave behind defective parts of the cartilage which may require a second surgery.
• Poor visual input for surgeons causes difficulty in learning the tool movement in the confined space, which leads to clinical problems.
• Although endoscopic septoplasty tools have been around since 1991, but they only show tool movement if it is in the line of sight of the endoscope.
• Septoplasty is one of the most common types of nasal surgery
  • It is very important that surgical residents have the best tools that can minimize complications while they are learning to perform septoplasty.

The Solution

• We developed an application that visualizes nasal cartilage, scissor movement inside the nose, and predicts the line-of-cut of surgical scissors with no line-of-sight dependency.
  • We achieve this by using an EM sensor that has no line-of-sight dependency.
  • We place one sensor on the patient’s forehead, one on the surgical scissors, and use an EM pointer to trace the patient’s anatomy.
  • The sensor on patient’s forehead removes the effect of patient movement during the surgery.
  • The pointer tool is used to estimate patient’s cartilage shape with a planar convex hull.
  • The EM sensor on the scissors estimates the scissor blade position relative to the cartilage, which is used to predict the line of cut on the cartilage.
  • Additionally, we also developed a tool to calibrate the EM sensor position and orientation relative to the scissor blade.

Outcomes and Results

• We attached a sensor to the cardboard, and traced lines to cut
• We then used our system to validate the line-of-cut prediction by cutting without looking at the cardboard.
• Below is an image of the result of cutting the cardboard

Future Work

• Using mesh for better approximation of deviated septum surface.
• Develop septum surface reconstruction with randomized surface touching.
• Recommend the location of the next surgical cut using an atlas collected from many surgeries

Lessons Learned

• Treat the process of validating data collection like any algorithm

Credits

• Felix developed the septum reconstruction concept, scissor training procedure and algorithm, and line of cut prediction algorithm.
• Michael developed the septum reconstruction algorithm, GUI, data processing pipeline, EM sensor data parser, and visualization platform.

Publications

• We plan to submit a paper to medical journal this summer

Support by and Acknowledgements

• Thanks to Narges Ahmidi, Dr. Masaru Ishii, Satyanarayana Vedula, Dr. Gregory Hager.