Abstract

Introduction: The lack of haptic (touch) feedback in current robotic surgery systems has limited its use in many areas of Otorhinolaryngology, including skull base surgery. We review the technical challenges to implementing haptic feedback in robotic surgery, including system instability, and we assess the feasibility and utility of adding haptic feedback in transoral robotic surgery (TORS).

Study Design: Observational study as part of a wider randomized-control trial of haptic feedback in TORS.

Methods: A previously developed vibrotactile haptic feedback system composed of accelerometer-based sensors and voice-coil actuators was mounted to a da Vinci robot. Using a validated simulator for transoral robotic posterior hemiglossectomy, 20 Otorhinolaryngology residents, 4 fellows and 5 attending surgeons performed simulated surgeries with and without haptic feedback of instrument vibrations. Subjects then completed a questionnaire assessing whether they noticed the haptic feedback and whether they preferred operating with or without haptic feedback.

Results: Overall, 16 of the 29 subjects (55.2%) noticed the presence of haptic feedback during the simulated surgeries. Most resident trainees with minimal prior robotic surgery experience were unaware of the feedback, while most fellows and attending physicians recognized the presence of haptic feedback (40% of residents vs. 88.9% of fellow/attending surgeons recognized haptic feedback, p=0.014). Of those subjects who noticed the feedback, most (81.3%) preferred to operate with haptic feedback.

Conclusions: The finding that most novice robotic surgeons failed to recognize the addition of haptic feedback suggests that feedback feels natural and expected in robotic surgery. Adding haptic feedback to existing TORS platforms is feasible, and initial results indicate that most Otolaryngologists prefer the addition of haptic feedback.

Methods and Materials

VerroTouch, a previously developed system that provides haptic feedback for the da Vinci robot, uses accelerometers mounted to the arms of the patient-side cart to measure instrument vibrations. These vibration signals are processed and used to drive voice-coil actuators mounted to the micromanipulators of the surgeon console. These actuators reproduce instrument vibrations at the surgeon's fingertips to provide real-time vibrotactile haptic feedback (see Figure 1).

Using a validated simulator for transoral robotic posterior hemiglossectomy (Figure 2), 20 Otolaryngology residents, 4 fellows and 5 attending surgeons performed simulated robotic surgeries with and without haptic feedback of instrument vibrations. All simulated surgeries were performed using an Intuitive da Vinci S system. Subjects then completed a questionnaire assessing whether they noticed haptic feedback and whether they preferred operating with or without feedback. P-values were calculated using Pearson's chi-squared test. A p-value of less than 0.05 was considered to be statistically significant.

Results

Most resident trainees with minimal prior robotic surgical experience failed to notice haptic feedback, while most fellow or attending surgeons recognized the presence of feedback (40% of residents vs. 88.9% of fellow/attending surgeons recognized haptic feedback, p=0.014). Of those subjects that noticed haptic feedback, the majority (81.3%) preferred operating with haptic feedback. The most common justifications provided were that haptic feedback improves awareness of instrument/tissue interactions (8 subjects), prevents instrument collisions (4 subjects) and feels more natural (3 subjects). Of the 4 subjects that preferred operating without haptic feedback, 2 found the feedback distracting, 1 felt that there was no benefit compared to visual input alone and 1 subject was an expert TORS surgeon who was used to operating without haptic feedback. There were no statistically significant differences between residents, fellows or attending surgeons with respect to their preference for haptic feedback (p=0.52) (see Figure 3).

Discussion

The finding that the majority of inexperienced robotic surgeons fail to recognize the presence of haptic feedback suggests that vibrotactile feedback feels natural and expected in transoral robotic surgery. This is not surprising given that haptic feedback is unavoidable in the more familiar settings of open and endoscopic surgery. That most experienced robotic surgeons recognize the presence of haptic feedback is also not surprising because these individuals are accustomed to the da Vinci surgical interface and have learned to compensate for its lack of haptic feedback. Additionally, the finding that most subjects preferred operating with haptic feedback shows that inexperienced and experienced TORS surgeons alike find haptic feedback to be a valuable addition to the da Vinci’s surgical interface.

Conclusions

This preliminary study demonstrates that adding haptic feedback to existing TORS platforms is feasible and may decrease cognitive load and improve performance. Vibrotactile feedback feels natural and is preferred by both novice and experienced TORS surgeons.

References