Ergonomics of robotic orthopedic surgery: a program to simultaneously improve operating room efficiency and quality of care

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Adult reconstructive orthopedic surgery in the United States is facing an imminent logjam due to the increasing divergence of the demand for services and the ability for the community to supply those services. In combination with several other factors, a perfect storm is brewing that may leave the system overtaxed and the patient population suffering from either a lack of treatment, or treatment by less qualified providers. A key component to improving the overall efficiency of surgical care is to introduce enabling technologies that can effectively increase the throughput while simultaneously improving the quality of care. One such enabling technology that has proven itself in many industries is robotics, which has recently been introduced in surgery with even more recent applications in orthopedic surgery. A surgeon interactive robotic arm has been developed for partial knee arthroplasty (PKA) and total hip arthroplasty (THA).

Data for operating room skin-to-skin time was recorded for 8, 656 robotically guided PKA procedures spanning across 208 surgeons and 86 hospitals. The average skin-to-skin time across all cases was 83±26 minutes (range: 28 – 214 minutes). The data was further analyzed to produce a learning curve for each surgeon defined as the number of cases the surgeon performed before reaching a unique steady state time. Across all surgeons, the average learning curve was 14 cases. Five of the 86 surgical sites were identified as the most efficient throughout their robotically guided PKA procedures based on skin-to-skin time and average surgeon learning curve. These five sites exhibited an average skin-to-skin time of 68 minutes. In addition we also identified five lowest efficiency sites based on the same criteria. These sites exhibited an average skin-to-skin time of 109 minutes. In an effort to establish an efficiency benchmarking program, a pilot study was initiated to analyze the operating room workflow and identify the elements contributing to efficiency of these ten sites.

The pilot study consists of video data collection to accurately record the timeline of each procedural task throughout the workflow of a robotically guided PKA procedure. Two camera angles are set up to capture both surgical staff group dynamics and individual procedural steps. Observational data is also collected through surgeon and operating room staff questionnaires through a voice of the customer format. Video data is analyzed by three independent reviewers to identify the procedural tasks and determine areas of task overlap capable of contributing to increased surgical efficiency. Video recorded and observational data will be used to create an optimal task allocation workflow between the user and the robotic arm. In addition results of the pilot study are expected to uncover unmet improvement opportunities in the interaction of the technology and its users.

Our data indicates that there are contributing factors to the efficiency of a robotically guided PKA procedure. Frequency of procedures, differences in workflow, and use of task overlap can all affect overall efficiency. By studying the most efficient sites we plan to extract generalizable concepts of efficiency that can be applied through user training and improvements in both the software and hardware of the technology. These concepts will be implemented at less efficient sites to measure their effectiveness at improving surgical efficiency over time.

The efficiency benchmarking program will aim to establish methods for best practices in achieving efficiency throughout a robotically guided PKA procedure. The optimized task allocation workflow will be utilized to reduce the complexity of the technology and increase ease of use.