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Robotics in Orthopedics: A Brave New World

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Robotics in Orthopedics: A Brave New World

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Robotics are here to stay- at least in Healthcare.

Future healthcare projections consider that the global population has doubled over the past 45 years. By 2020, 95% of the world’s 8 billion people will live in developing nations. [1.] Concomitant with this growth, we have experienced an exponential growth in technology. During this time period, we have witnessed the most rapid increase in technological advance in our history and the growth curve continues to be steep. Compared to the technological improvements in the automotive industry that began back in the late 1940s, we have witnessed an exponential growth just in the past several years with the development of electric cars, guidance systems, and a commitment to driverless vehicles for commercial and private use.

Healthcare has experienced a similar type of evolution as it seeks to address the growing population with the decreasing number of physicians and healthcare workers. Significant effort has been focused on eliminating the monotonous and repetitive work that healthcare workers perform. Providers could then focus more on direct patient care and decrease their overall workload. In addition, there has been an increased interest in using technology to refine the surgical procedures that we perform repetitively.

Over 13.6 billion is estimated to be spent by 2019 on surgical robotics to address many of these healthcare issues. In November of 2016, Tractica[2.] reported that healthcare robotic shipments would surpass 10,000 units annually by 2021. The demand for surgical, rehabilitation and hospital robots will continue to rise driven by the declining cost of robotic production, the increasing labor shortages and the successful pilot projects that demonstrated the efficacy of this evolving technology. Robotics will see the greatest growth in the surgical area while noninvasive radio-surgical systems will also demonstrate significant growth. Other
areas of robotic development include emergency response robotic systems, prosthetics and endoskeleton development, assistive rehabilitation systems and non-medical hospital systems

As the world population continues to grow and the baby boomers enter into the over age 65 population, a decline in the number of physicians and healthcare professionals is predicted. As a result, Tractica forecast that robots will have a growing presence in the healthcare system not only in North America but also an exponential growth increase in Europe and Asia.

Robotic assisted surgery had limited adoption when initially introduced in the late 1980s. The initial introduction of an autonomous robot into orthopedic surgery was in 1992 with the introduction of Robodoc for the performance of hip arthroplasty on the femoral side only.[3,4] Early adoption was limited due to the limited application of the technology, the cumbersome nature of the equipment, and technical complications at the time of surgery [5]. Intuitive Surgical introduced the da Vinci which was first approved by the FDA in 2000 for laparoscopic surgery. At the time of its initial roll out in 2002, approximately 1% of the prostatectomies in the United States were robotically performed. In 2014, more than 89% of the prostatectomies were performed robotically. The growth worldwide continues to increase. Additional competition is evolving, stimulating further improvements in efficiency, adaptability, and cost reduction.

In the orthopedic arena, robotics were first introduced more than thirty years ago [3,6]. However adoption was very limited until recently. Ongoing surgical challenges faced by orthopedic surgeons result from the use of manual instruments causing inconsistency in implant placement and bone removal, the introduction of human error, and less predictable outcomes due to lack of reproducible accuracy. The surgeon’s desire to achieve the best outcome for the patient fueled interest in alternative techniques to achieve this goal.

The evolution of robotics allows for advanced surgical planning, precision robotic machining of bone with reduced error resulting in improved implant-bone contact, optimization of component placement, and optimization of the
mechanical alignment [7,8, 9]. All of these factors have stimulated an increased interest in robotics.

The growing body of clinical research studies and presentations has also improved the perceptions of robotic surgery. These studies have confirmed the reliability of implant position resulting in a decrease in early failures. Restoration of mechanical alignment, improved implant positioning and the reduction in the percentage of outliers has increased the interest in robotics. The longer term clinical outcomes are still needed to validate the benefits of these changes.

The earliest adoption was limited because efficiencies were not improved, a significant capital expenditure was required and initial changes in outcomes were not evident [10,11]. The initial robotic machines were cumbersome and unreliable therefore were often relegated to the back storage area and were underutilized. Since 2007, interest has grown steadily in the arthroplasty community as well as in the public for new technology. Patient demands for new technology has been driven by an increase in access to information via social media and direct to consumer marketing.

Traditional Delivery Model

The traditional operating room delivery model requires extensive implant inventory, storage, and management. All instruments systems require extensive set up time, break down and cleaning time, and re-sterilization of multiple trays. Up to 8 to 12 trays of specialized instruments may be required for one joint replacement procedure. This model is inefficient, labor intensive, and not cost-effective. With a focus on cost-effectiveness, alternative methods to the traditional delivery model have been sought. Reduced need for instrumentation can result in a substantial savings for the device manufacturers, the hospitals and cost of delivery of care. When new instruments or implant designs are introduced or modified after initial product release, the capital costs for change in
instrumentation can be expensive. When robotics is utilized, a change in the workflow or programing is usually all that is required.

Instrument loss, replacement, repair and maintenance are a substantial cost to the medical industry. It has been estimated to exceed $15 million per year. Robotics reduces this capital expense.

What are the potential benefits?

The evolution of the surgical workflow has improved, resulting in an improvement in efficiency and reduction in surgical time. Surgical maps are computer generated preoperatively to achieve optimal mechanical alignment, implant sizing and placement. The surgeon can review and modify the surgical plan prior to initiating the procedure and perform a mental walk thru of the procedure. The use of the robotic system has resulted in a decrease in blood loss, and improvement in accuracy [12,6,13,14].

What does the future hold?

Today, robotic tools and more anatomically designed joint implants are available. In addition, knee implants may now be custom designed. The future operating room could easily incorporate multiple technologies to allow the surgeon to preoperatively plan the surgical procedure, utilize a robotically guided cutting system to achieve high accuracy on the bone cuts and achieve optimal mechanical alignment while utilizing very few instruments on the back table. By utilizing either a custom implant specifically designed for the patient or a preselected implant from an off-the-shelf design, the need for additional pans of instrumentation on the back table would be eliminated. The cost of sterilization and processing, storage, and instrument loss or breakage would be significantly
reduced. In addition, the inefficiencies of room turnover and preparation for the start of the next case would be significantly decreased. The time saved would facilitate the performance of more cases in a normal working day. This results in improved cost utilization of the operating room, the staff and the equipment.

3-D printing is another evolving technology that could also benefit from the use of robotics. 3-D printing generates custom implants that address a multitude of bony abnormalities. The information can be loaded into the robotic surgical instrument to perform the surgery with a higher degree of accuracy and restore the optimal mechanical environment for the success of the implant and the patient.

Finally, robotic tools may assist in repetitive learning and training of the next generation of surgeons. The robot provides excellent feedback at the time of use and can follow outcomes and changes in technique over time. The ability to accurately record the data points at the time of surgery is an excellent research tool for review of the outcomes both early and late following surgical intervention.

To quote William Pollard: Without change there is no innovation, creativity, or incentive for improvement. Those who initiate change will have a better opportunity to manage the change that is inevitable.

References:


