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AN EMPIRICAL REVIEW ON ROBOTIC ARM BASED SURGICAL MANEUVER TECHNOLOGY IN MEDICAL SCIENCES

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ABSTRACT

Robotic surgery is a method to perform surgery using very small tools attached to a robotic arm. The surgeon controls the robotic arm with a computer. Different types of computer-assisted surgical systems can be used for pre-operative planning, surgical navigation and to assist in performing procedures. One type is computer-assisted surgical systems, commonly called robotic-assisted surgical systems or robotic surgery. Humanoid robotics is a novel perplexing field these days. To co-operate with human beings, humanoid robots also have the same feature of human like form and structure, but more significantly, they must prepared human like behavior regarding the intelligence communication and also the motion. Later, the solicitation of robotics in the arena of surgery has open field of exploration that has help to ensure the dexterity, accuracy, durability and the ability for repetition. With the wide acceptance in robotic surgery, the drive to provide smaller, more efficient and less expensive equipment is driving researchers to reach unheard of heights. Robotic surgery has been successfully implemented in several hospitals around the globe and has received worldwide acceptance. The force of this paper is to enlighten the usage and applications of surgical arms used for the different surgery.

Keywords - Robotic Surgery, Automated Surgical Equipments, Robotic Medical Devices

INTRODUCTION

Robotic surgery is a type of minimally invasive surgery. “Minimally invasive” means that instead of operating on patients through large incisions, we use miniaturized surgical instruments that fit through a series of quarter-inch incisions. When performing surgery with the da Vinci Si - the world’s most advanced surgical robot - these miniaturized instruments are mounted on three separate robotic arms, allowing the surgeon maximum range of motion and precision. The da Vinci’s fourth arm contains a magnified high-definition 3-D camera that guides the surgeon during the procedure. A number of research works has been performed on the endoscopic surgery [1].

Robotics-assisted minimally-invasive surgery (RAMIS) is a surgical approach in which operations are performed using long, narrow surgical tools and an endoscope (camera), which are held by robotic arms and inserted into a patient through small incisions [2].

The surgeon controls these instruments and the camera from a console located in the operating room. Placing his fingers into the master controls, he is able to operate all four arms of the da Vinci simultaneously while looking through a stereoscopic high-definition monitor that literally places him inside the patient, giving him a better, more detailed 3-D view of the operating site than the human eye can provide. Every movement he makes with the master controls is replicated precisely by the robot. When necessary, the surgeon can even change the scale of the robot's movements: If he selects a three-to-one scale, the tip of the robot's arm will move just one inch for every three inches the surgeon's hand moves. And because of the console's design, the surgeon's eyes and hands are always perfectly aligned with his view of the surgical site, minimizing surgeon fatigue.

An ultimate goal and impact is to give the specialist extraordinary control in an insignificantly nature. As one of our specialists notes, "It's as though I've scaled down my body and gone inside the patient." Utilizing this progressed engineering, our specialists can perform a developing number of complex urological, gynecological, cardiothoracic and general surgical techniques. Since these systems can now be performed through little entry points, our patients encounter various profits contrasted with open surgery, including:

- Less trauma on the body
- Minimal scarring, and
- Faster recovery time

SURGICAL ROBOTIC SYSTEMS

Surgical robotic systems can be divided into two major groups: specialized and versatile systems. Specialized systems focus either on a dedicated surgical technique, like endoscopic surgery with the da Vinci surgical system by Intuitive Surgical and Artemis or on the treatment of a specific medical disease. These systems can fulfill the dedicated task very well, but link the financial amortization in the clinic to single medical procedures. With ongoing research in medical treatment, many of these specialized robotic systems are likely to lose their niche. On the other hand, today's versatile systems often still base on the adaptation of industrial robots. Industrial robots are targeted on high-absolute accuracy which is achieved by stiff structures and thus relatively high mass. Safety and adequacy in the unstructured and crowded environment of an operating room combined with close human robot interaction are therefore at least questionable.

Medical robots may be classified in many ways: by manipulator design (e.g., kinematics, actuation); by level of autonomy (e.g., preprogrammed versus teleoperation versus constrained cooperative control), by targeted anatomy or technique (e.g., cardiac, intravascular, percutaneous, laparoscopic, microsurgical); intended operating environment etc. [3].

Minimally Invasive Surgery (MIS) is a type of surgery whereby the surgical operation is done through small incisions. It has been rapidly developed since the introduction of laparoscopic cholecystectomy in late 1989 [1]. The basic operation concept of MIS is to insert the surgical instruments, e.g., the laparoscope, endoscopic camera, etc., into patient's body through small incisions so that the surgical 338 C.-H. Kuo and J.S. Dai operations can be implemented inside the patient's body at the proximal end of the tools that are maneuvered by surgeon's hands outside patient's body. Compared to open surgery, MIS has many advantages such as reduced risk of infection, less pain, bleeding and scarring, shorter hospitalization, and reduced recovery time, etc. It hence gradually became popular and dramatically replaced many traditional surgical procedures in open surgeries [4].

MIS consists in achieving operation through small penetration points in the body, equipped with trocars [5]

Minimally invasive surgery (MIS) has become a promising option for a great number of medical interventions (like coronary heart surgery) [6].

ADVANTAGES OF ROBOTIC SURGERY

The utilization of a machine comfort to perform operations from a separation opens up the thought of telesurgery, which would include a specialist performing fragile surgery miles far from the patient. In the event that the specialist doesn't need to remained over the patient to perform the surgery, and can control the automated arms from a machine station simply a couple of feet far from the patient, the following step would be performing surgery from areas that are considerably more distant away. In the event that it were conceivable to utilize the machine support to move the mechanical arms progressively, then it would be feasible for a specialist in California to work on a patient in New York. A significant deterrent in telesurgery has been idleness - the time defer between the specialists moving his or her hands to the automated arms reacting to those developments. Presently, the specialist must be in the room with the patient for automated frameworks to respond in a flash to the specialist's hand developments.

MIS leads to several advantages for patients. These are, among others [7]

- Small incisions reduce pain and trauma
- Shorter residence at hospital and shorter rehabilitation time
- Cosmetical advantages due to small incisions

Because RAMIS is performed through small incisions in the patient's body, robotic systems for minimally-invasive surgery must pivot the surgical tools about these incisions. This pivoting constraint is called a Remote Center-of-Motion (RCM), and it is an important task for any RAMIS system, be it experimental or commercial [8].

Having fewer personnel in the operating room and allowing doctors the ability to operate on a patient long-distance could lower the cost of health care in the long term. In addition to cost efficiency, robotic surgery has several other advantages over conventional surgery, including enhanced precision and reduced trauma to the patient. For instance, traditional heart bypass surgery requires that the patient's chest be "cracked" open by way of a 1-foot (30.48-cm) long incision. However, with the da Vinci system, it's possible to operate on the heart by making three or four small incisions in the chest, each only about 1 centimeter in length. Because the surgeon would make these smaller incisions instead of one long one down the length of the chest, the patient would experience less pain, trauma and bleeding, which means a faster recovery.

Robotic assistants can also decrease the fatigue that doctors experience during surgeries that can last several hours. Surgeons can become exhausted during those long surgeries, and can experience hand tremors as a result. Even the steadiest of human hands cannot match those of a surgical robot. Engineers program robotic surgery systems to compensate for tremors, so if the doctor's handshakes the computer ignores it and keeps the mechanical arm steady.

Minimally invasive surgery presents a constrained working environment for both surgeons and mechanical devices designed to assist them [9].

THE DA VINCI SURGICAL SYSTEM

A product of the company Intuitive Surgical, the da Vinci Surgical System is perhaps the most famous robotic surgery apparatus in the world. It falls under the category of telesurgical devices, meaning a human directs the motions of the robot. In a way, this makes the robot a very expensive high-tech set of tools.

On July 11, 2000, the U.S. Food and Drug Administration (FDA) approved the da Vinci Surgical System for laparoscopic procedures, making it the first robotic system allowed in American operating rooms. The da Vinci uses technology that allows the human surgeon to get closer to the surgical site than human vision will allow, and work at a smaller scale than conventional surgery permits. The $1.5 million da Vinci system consists of two primary components:

- A viewing and control console
- A surgical arm unit that includes three or four arms, depending on the model

In using da Vinci for surgery, a human surgeon makes three or four incisions (depending on the number of arms the model has) -- no larger than the diameter of a pencil -- in the patient's abdomen, which allows the surgeons to insert three or four stainless-steel rods. The robotic arms hold the rods in place. One of the rods has two endoscopic cameras inside it that provide a stereoscopic image, while the other rods have surgical instruments that are able to dissect and suture the tissue. Unlike in conventional surgery, the doctor does not touch these surgical instruments directly.

Sitting at the control console a few feet from the operating table, the surgeon looks into a viewfinder to examine the 3-D images being sent by the camera inside the patient. The images show the surgical site and the two or three surgical instruments mounted on the tips of the surgical rods. The surgeon uses joystick-like controls located underneath the screen to manipulate the surgical instruments. Each time the surgeon moves one of the joysticks, a computer sends an electronic signal to one of the instruments, which moves in sync with the movements of the surgeon's hands. Working together, surgeon and robot can perform complete surgical procedures without the need for large incisions. Once the surgery is complete, the surgeons remove the rods from the patient's body and close the incisions.

Robot-guidance (both hands-on cooperative and remote teleoperative control mode) employed spatial motion constraints generated by virtual fixtures derived from complex geometry can assist users in skilled manipulation tasks, while maintaining desirable properties such as collision avoidance and safety [10].

SHARED-CONTROL ROBOTIC SURGERY SYSTEMS

Shared-control robotic systems aid surgeons during surgery, but the human does most of the work. Unlike the other robotic systems, the surgeons must operate the surgical instruments themselves. The robotic system monitors the surgeon's performance and provides stability and support through active constraint. Active constraint is a concept that relies on defining regions on a patient as one of four possibilities: safe, close, boundary or forbidden. Surgeons define safe regions as the main focus of a surgery. For example, in orthopedic surgery, the safe region might be a specific site on the patient's hip. Safe regions don't border soft tissues.

In orthopedic surgery, a close region is one that borders soft tissue. Since orthopedic surgical tools can do a lot of damage to soft tissue, the robot constrains the area the surgeon can operate within. It does this by providing

haptic responses, also known as force feedback. As the surgeon approaches the soft tissue, the robot pushes back against the surgeon's hand.

As the surgeon gets closer to soft tissue, the instrument enters the boundary region. At this point, the robot will offer more resistance, indicating the surgeon should move away from that area. If the surgeon continues cutting toward the soft tissue, the robot locks into place. Anything from that point on is the forbidden region.

LITERATURE REVIEW

Surgical robotic assistant systems work interactively with surgeons to extend human's capabilities in carrying out a variety of surgical tasks. They usually are human-machine collaborative systems (HMCS) that are operated directly by the surgeon and augment the surgeon's ability to manipulate surgical instruments in surgery [11].

To analyze various factors and aspects, a number of research papers and related work are analyzed. Following are the excerpts of assorted research work

Roderick et. al. (2007) – In this research work, a novel and effective technique is explained for isotropy-based kinematic optimization of specific robot characteristics. The approach has advantages over existing techniques when designing robotic systems for specific, unconventional tasks, and for constrained motion. In this paper, the technique is used to assist in the selection of a remote center-of-motion (RCM) location for a research testbed that is being developed at CSTAR to study robotics-assisted minimally-invasive surgery. The optimization technique allows isotropy to be considered with respect to the surgical tool tip while operating under the RCM constraint. Global isotropy over a minimally-invasive surgical workspace is evaluated for a set of candidate RCM locations, and an optimal RCM location with respect to isotropy is selected. The isotropy results are compared with experimental data for a number of candidate RCM locations. The experimental results confirm the usefulness of the optimization technique.

Medical Robotics in Computer-Integrated Surgery, Russell H. Taylor*, Fellow, IEEE,* and Dan Stoianovici - This paper provides a broad overview of medical robot systems used in surgery. After introducing basic concepts of computer-integrated surgery, surgical CAD/CAM, and surgical assistants, it discusses some of the major design issues particular to medical robots. It then illustrates these issues and the broader themes introduced earlier with examples of current surgical CAD/CAM and surgical assistant systems. Finally, it provides a brief synopsis of current research challenges and closes with a few thoughts on the research/industry/clinician teamwork that is essential for progress in the field.

Robotics for Minimally Invasive Surgery: A Historical Review from the Perspective of Kinematics Chin-Hsing Kuo et. al. 2009 – This work is devoted to reviewing the development of robotics from the perspective of kinematics in MIS during the past twenty years taking account of the kinematic structures of the manipulator design of the robots. An exclusively kinematic geometry, namely the "remote center-of-motion", for MIS is reviewed by which a classification of MIS robots is concluded.

Dynamic Task / Posture Decoupling for Minimally Invasive Surgery Motions: Simulation Results MicaEl Michelin et. al. - This paper depicts with the use of an original dynamic task / posture decoupling coutrol algorithm that allows a robot to achieve motions under the constraint of moving through a fixed point. This work takes place in the context of minimally invasive surgery

wbere the tool is telemanipulated by the surgeon through B Penetration point: the trocar fined on the patient. The algorithm is based on the dynamic control in the operational space of a redundant robot: the total control torque is decoupled into a task behavior torque and a posture behavior torque. By minimizing the contact force applied to the trocar (or equivalently, by forcing to zero the distance between the instrument passing through the trocar and the current location of the trocar), we compute the poshlre bebaviar torque guaranteeing that the trocar constraint is satisfied. Simulation results highlight the performaoce of this algor

Resolved Motion Rate Control of Manipulators and Human Prostheses 1969 Daniel e. Whitney, member, IEEE Abstract-The kinematics of remote manipulators and human prostheses is analyzed for the purpose of deriving resolved motion rate control. That is, the operator is enabled to call for the desired hand motion directly along axes relevant to the task environment. The approach suggests solutions to problems of coordination, motion under task constraints, and appreciation of forces encountered by the controlled hand.

Resolving Manipulator Redundancy Under Inequality Constraints 1994 Fan-Tien Cheng, Tsing-Hua Chen, and York-Yih Sun - In this manuscript, these constraints are considered into the general formulation of the redundant inverse kinematic problem. Tu take these physical constraints into account, the computationally efficient Compact Quadratic Programming (QP) method is formed to resolve the constrained kinematic redundancy problem. In addition, the Compact- Inverse QP method is also formulated to remedy the unescapable singularity problem with inequality Constraints. Two examples are given to demonstrate the generality and superiority of these two methods: to eliminate the drit‘l phenomenon caused by self motion and to remedy saturation-type nonlinearity problem.

Robotic arms DLUs for performing surgical tasks, 2014 Patent - US Patent 8663203 B2 - Disposable loading units (DLUs) configured for mounting to a robotic arm for performing at least one surgical task are presented. Each DLU includes an attachment platform having at least one connector for engaging at least one connector on a distal end of the robotic arm for connecting the DLU to the robotic arm, a head portion connected to the attachment platform at one end and configured for housing an electro-mechanical actuation assembly therein, and at least one surgical tool member extending from the head portion and operatively associated with the electro-mechanical actuation assembly for controlling the operation and movement of the at least one surgical tool member. The at least one surgical tool member may include a cutting assembly, an aortic hole punch assembly, a lasing assembly, a coring assembly, or a vascular suturing assembly.

The Future of Robotic Thyroid Surgery and Neck Dissection, F. Christopher Holsinger MD, FACS , 2013 - The present generation of robotic technology has ushered in a revolution in surgical technique for selected patients undergoing thyroidectomy, beginning with Chung’s axillary and culminating with Terris’ facelift approach. Using these complementary approaches, Koh and colleagues have demonstrated the feasibility and reproducibility of robotic neck dissection, with outcomes in early studies comparable to open technique. As new robotic systems come to market and as the current platform is further refined, surgeons can expect smaller systems, with flexible arms, stereo-endoscopes, and new instrumentation to allow greater innovation and refinement of surgical technique in thyroidectomy, parathyroid surgery, and neck dissection.

Robotic Surgery in Gynecologic Oncology, Javier F. Magrina - The application of robotic technology for abdominal and pelvic surgery has had a strong impact in gynecologic oncological surgery. The most influential result is a decrease in the number of procedures performed by laparotomy. Many centers have evolved from a laparotomy to a robotic approach, and centers that were performing advanced laparoscopic procedures have discovered the advantages of robotic technology for gynecologic oncological operations. When analyzing perioperative outcomes for laparotomy, laparoscopy, and robotic surgery, three major benefits appear in almost all studies: reduced blood loss, shorter hospitalization, and shorter recovery to normal activities. Operating times are similar or longer, and postoperative complications are similar or reduced, for laparoscopy and robotic surgery patients.

APPLICATIONS

GENERAL SURGERY - In early 2000 the field of general surgical interventions with the daVinci device was explored by surgeons at Ohio State University. Reports were published in esophageal and pancreatic surgery for the first time in the world and further data was subsequently published by Horgan and his group at the University of Illinois and then later at the same institution by others. In 2007, the University of Illinois at Chicago medical team, led by Prof. Pier Cristoforo Giulianotti, reported a pancreatectomy and also the Midwest's first fully robotic Whipple surgery. In April 2008, the same team of surgeons performed the world's first fully minimally invasive liver resection for living donor transplantation, removing 60% of the patient's liver, yet allowing him to leave the hospital just a couple of days after the procedure, in very good condition. Furthermore the patient can also leave with less pain than a usual surgery due to the four puncture holes and not a scar by a surgeon.

CARDIOTHORACIC SURGERY - Robot-assisted MIDCAB and Endoscopic coronary artery bypass (TECAB) operations are being performed with the da Vinci system. Mitral valve repairs and replacements have been performed. East Carolina University, Greenville (Dr Wandolph Randolph Chitwood), Saint Joseph's Hospital, Atlanta (Dr Douglas A. Murphy), and Good Samaritan Hospital, Cincinnati (Dr J. Michael Smith) have popularized this procedure and proved its durability with multiple publications. Since the first robotic cardiac procedure performed in the USA in 1999, The Ohio State University, Columbus (Dr. Robert E. Michler, Dr. Juan Crestanello, Dr. Paul Vesco) has performed CABG, mitral valve, esophagectomy, lung resection, tumor resections, among other robotic assisted procedures and serves as a training site for other surgeons. In 2002, surgeons at the Cleveland Clinic in Florida (Dr. Douglas Boyd and Kenneth Stahl) reported and published their preliminary experience with minimally invasive "hybrid" procedures. These procedures combined robotic revascularization and coronary stenting and further expanded the role of robots in coronary bypass to patients with disease in multiple vessels. Ongoing research on the outcomes of robotic assisted CABG and hybrid CABG is being done by Dr. Robert Poston.

CARDIOLOGY AND ELECTROPHYSIOLOGY - The Stereotaxis Magnetic Navigation System (MNS) has been developed to increase precision and safety in ablation procedures for arrhythmias and atrial fibrillation while reducing radiation exposure for the patient and physician, and the system utilizes two magnets to remotely steerable catheters. The system allows for automated 3-D mapping of the heart and vasculature, and MNS has also been used in interventional cardiology for

guiding stents and leads in PCI and CTO procedures, proven to reduce contrast usage and access tortuous anatomy unreachable by manual navigation. Dr. Andrea Natale has referred to the new Stereotaxis procedures with the magnetic irrigated catheters as "revolutionary."[*5*] The Hansen Medical Sensei robotic catheter system uses a remotely operated system of pulleys to navigate a steerable sheath for catheter guidance. It allows precise and more forceful positioning of catheters used for 3-D mapping of the heart and vasculature. The system provides doctors with estimated force feedback information and feasible manipulation within the left atrium of the heart. The Sensei has been associated with mixed acute success rates compared to manual, commensurate with higher procedural complications, longer procedure times but lower fluoroscopy dosage to the patient. At present, three types of heart surgery are being performed on a routine basis using robotic surgery systems. These three surgery types are:

- Atrial septal defect repair – the repair of a hole between the two upper chambers of the heart,
- Mitral valve repair – the repair of the valve that prevents blood from regurgitating back into the upper heart chambers during contractions of the heart,
- Coronary artery bypass – rerouting of blood supply by bypassing blocked arteries that provide blood to the heart.

As surgical experience and robotic technology develop, it is expected that the applications of robots in cardiovascular surgery will expand.

COLON AND RECTAL SURGERY - Many studies have been undertaken in order to examine the role of robotic procedures in the field of colorectal surgery. Results to date indicate that robotic-assisted colorectal procedures outcomes are "no worse" than the results in the now "traditional" laparoscopic colorectal operations. Robotic-assisted colorectal surgery appears to be safe as well. Most of the procedures have been performed for malignant colon and rectal lesions. However, surgeons are now moving into resections for diverticulitis and non-resective rectopexies (attaching the colon to the sacrum in order to treat rectal prolapse.) When evaluated for several variables, robotic-assisted procedures fare equally well when compared with laparoscopic, or open abdominal operations. Study parameters have looked at intraoperative patient preparation time, length of time to perform the operation, adequacy of the removed surgical specimen with respect to clear surgical margins and number of lymph nodes removed, blood loss, operative or postoperative complications and long term results. More difficult to evaluate are issues related to the view of the operative field, the types of procedures that should be performed using robotic assistance and the potential added cost for a robotic operation. Many surgeons feel that the optics of the 3-Dimensional, two camera stereo optic robotic system are superior to the optical system used in laparoscopic procedures. The pelvic nerves are clearly visualized during robotic-assisted procedures. Less clear however is whether or not these supposedly improved optics and visualization improve patient outcomes with respect to postoperative impotence or incontinence, and whether long term patient survival is improved by using the 3-Dimensional optic system. Additionally, there is often a need for a wider, or "larger" view of the operative field than is routinely provided during robotic operations. The close-up view of the area under dissection may hamper visualization of the "bigger view", especially with respect to ureteral protection.

GASTROINTESTINAL SURGERY - Multiple types of procedures have been performed with either the 'Zeus' or da Vinci robot systems, including bariatric surgery and gastrectomy for cancer. Surgeons at various universities initially published case series demonstrating different

techniques and the feasibility of GI surgery using the robotic devices. Specific procedures have been more fully evaluated, specifically esophageal fundoplication for the treatment of gastroesophageal reflux and Heller myotomy for the treatment of achalasia. Other gastrointestinal procedures including colon resection, pancreatectomy, esophagectomy and robotic approaches to pelvic disease have also been reported.

GYNECOLOGY - Robotic surgery in gynecology is one of the fastest growing fields of robotic surgery. This includes the use of the da Vinci surgical system in benign gynecology and gynecologic oncology. Between July 2005 and April 2008, 110 patients went under robotically assisted gynecological surgeries in Rochester General Hospital, New York. The records for these patients were reviewed to analyze the safety, effectiveness, and outcome of the surgeries done using the da Vinci system. Robotic surgery can be used to treat fibroids, abnormal periods, endometriosis, ovarian tumors, pelvic prolapse, and female cancers. Using the robotic system, gynecologists can perform hysterectomies, myomectomies, and lymph node biopsies. The need for large abdominal incisions is virtually eliminated. Robot assisted hysterectomies and cancer staging are being performed using da Vinci robotic system. The University of Tennessee, Memphis (Dr. T. Tillmanns, Dr. Saurabh Kumar), Northwestern University (Dr. Patrick Lowe), Aurora Health Center (Dr. Scott Kamelle), West Virginia University (Dr. Jay Bringman) and The University of Tennessee, Chattanooga (Dr. Donald Chamberlain) have extensively studied the use of robotic surgery and found it to improve morbidity and mortality of patients with gynecologic cancers. They have also for the first time reported robotic surgery learning curves for current and new users as a method to assess acquisition of their skills using the device. Dr.'s Joseph Prezzato and Burton Brodsky have utilized this equipment for gynecological procedures in Southeastern Michigan.

NEUROSURGERY - Several systems for stereotactic intervention are currently on the market. The NeuroMate was the first neurosurgical robot, commercially available in 1997.*[19*] Originally developed in Grenoble by Alim-Louis_Benabid's team, it is now owned by Renishaw. With installations in the United States, Europe and Japan, the system has been used in 8000 stereotactic brain surgeries by 2009. IMRIS Inc.'s SYMBIS(TM) Surgical System will be the version of NeuroArm, the world's first MRI-compatible surgical robot, developed for world-wide commercialization. Medtech's Rosa is being used by several institutions, including the Cleveland Clinic in the U.S, and in Canada at Sherbrooke University and the Montreal Neurological Institute and Hospital in Montreal (MNI/H). Between June 2011 and September 2012, over 150 neurosurgical procedures at the MNI/H have been completed robotized stereotaxy, including in the placement of depth electrodes in the treatment of epilepsy, selective resections, and stereotaxic biopsies.

ORTHOPEDICS - The ROBODOC system was released in 1992 by Integrated Surgical Systems, Inc. which merged into CUREXO Technology Corporation. Also, The Acrobot Company Ltd. developed the "Acrobot Sculptor", a robot that constrained a bone cutting tool to a pre-defined volume. The "Acrobot Sculptor" was sold to Stanmore Implants in August 2010. Stanmore received FDA clearance in February 2013 for US surgeries but sold the Sculptor to Mako Surgical in June 2013 to resolve a patent infringement lawsuit. Another example is the CASPAR robot produced by U.R.S.-Ortho GmbH & Co. KG, which is used for total hip replacement, total knee replacement and anterior cruciate ligament reconstruction. MAKO Surgical Corp (founded 2004) produces the RIO (Robotic Arm Interactive Orthopedic System) which combines robotics, navigation, and haptics for both partial knee and total hip replacement surgery. Blue Belt

Technologies received FDA clearance in November 2012 for the Navio™ Surgical System. The Navio System is a navigated, robotics-assisted surgical system that uses a CT free approach to assist in partial knee replacement surgery.

PEDIATRICS - Surgical robotics has been used in many types of pediatric surgical procedures including: tracheoesophageal fistula repair, cholecystectomy, nissen fundoplication, morgagni's hernia repair, kasai portoenterostomy, congenital diaphragmatic hernia repair, and others. On 17 January 2002, surgeons at Children's Hospital of Michigan in Detroit performed the nation's first advanced computer-assisted robot-enhanced surgical procedure at a children's hospital.

The Center for Robotic Surgery at Children's Hospital Boston provides a high level of expertise in pediatric robotic surgery. Specially-trained surgeons use a high-tech robot to perform complex and delicate operations through very small surgical openings. The results are less pain, faster recoveries, shorter hospital stays, smaller scars, and happier patients and families.

RADIOSURGERY - The CyberKnife Robotic Radiosurgery System uses image guidance and computer controlled robotics to treat tumors throughout the body by delivering multiple beams of high-energy radiation to the tumor from virtually any direction. The system uses a German KUKA KR 240. Mounted on the robot is a compact X-band linac that produces 6MV X-ray radiation. Mounting the radiation source on the robot allows very fast repositioning of the source, which enables the system to deliver radiation from many different directions without the need to move both the patient and source as required by current gantry configurations.

TRANSPLANT SURGERY - Transplant surgery (organ transplantation) has been considered as highly technically demanding and virtually unobtainable by means of conventional laparoscopy. For many years, transplant patients were unable to benefit from the advantages of minimally invasive surgery. The development of robotic technology and its associated high resolution capabilities, three dimensional visual system, wrist type motion and fine instruments, gave opportunity for highly complex procedures to be completed in a minimally invasive fashion. Subsequently, the first fully robotic kidney transplantations were performed in the late 2000s. After the procedure was proven to be feasible and safe, the main emerging challenge was to determine which patients would benefit most from this robotic technique. As a result, recognition of the increasing prevalence of obesity amongst patients with kidney failure on hemodialysis posed a significant problem. Due to the abundantly higher risk of complications after traditional open kidney transplantation, obese patients were frequently denied access to transplantation, which is the premium treatment for end stage kidney disease. The use of the robotic-assisted approach has allowed kidneys to be transplanted with minimal incisions, which has virtually alleviated wound complications and significantly shortened the recovery period. The University of Illinois Medical Center reported the largest series of 104 robotic-assisted kidney transplants for obese recipients (mean body mass index > 42). Amongst this group of patients, no wound infections were observed and the function of transplanted kidneys was excellent. In this way, robotic kidney transplantation could be considered as the biggest advance in surgical technique for this procedure since its creation more than half a century ago.

MERITS OF ROBOTIC ASSISTED SURGERIES

- Minimum amount of stress, trauma and pain to the patients

- Fewer risks of infection due to minimal invasive technology in robotic surgery
- Highest success rates with few complications when compared to traditional surgical procedures
- Requires less blood transfusions and the percentage of blood loss is considerably low
- Recovery rate enhancement
- Hospital stay is shortened facilitating people to undertake daily tasks at a quicker pace
- Reduced chances of scarring since procedures are done with small incisions
- Greatest benefit of having the highest precision
- Highest level of safety and comfort to patients
- The degree of control and flexibility of the surgery is greater

CONCLUSION AND SCOPE OF FUTURE WORK

Robotic surgery is a system to perform surgery utilizing little apparatuses joined to an automated arm. The specialist controls the mechanical arm with a machine. The eventual fate of mechanical surgery is about as guaranteeing as the human will to concoct better methods for finishing sensitive therapeutic systems. It is sensible to expect that the current preferences of automated surgery frameworks will be developed in the up and coming era of therapeutic mechanical technology. Uprooting human contact amid surgery may be taken to the following level with automated surgery frameworks equipped for working at more prominent separations between specialists control support and the patient side table apply autonomy. This would permit automated surgery to be directed with patients in an adjacent "clean room," decreasing or killing intraoperative disease. It is feasible for cutting edge therapeutic apply autonomy and automated surgery to lead surgical prep work remotely too. Headways in making mechanical surgery frameworks more fit for recreating the material feel and sensation a specialist encounters amid more obtrusive conventional methods would give the specialist the best of both planets. The specialist would pick up the accuracy and preferences of negligibly obtrusive techniques without losing the tactile data accommodating in making careful decisions amid automated surgery. Automated surgery is like laparoscopic surgery. It could be performed through more diminutive cuts than open surgery. The little, exact developments that are conceivable with this sort of surgery provide for it a few points of interest over standard endoscopic methods. The specialist can make little, exact developments utilizing this strategy. This can permit the specialist to do a methodology through a little cut that once might be possible just with open surgery. Once the automated arm is put in the guts, it is simpler for the specialist to utilize the surgical apparatuses than with laparoscopic surgery through an endoscope. The specialist can additionally see the regions where the surgery is performed all the more effortlessly. In the scope of future work, an effective algorithmic approach can be implemented using appropriate simulator so that the testing can be performed efficiently using medical surgical arm.

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