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Research Article

Integrating Medical Robots for Brain Surgical Applications

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Abstract

Neurosurgery has customarily been at the cutting edge of propelling innovations, adjusting new strategies and gadgets effectively with an end goal to build the security and viability of brain surgery procedures. Among these adjustments is the surgical robot technology. This paper features a portion of the all the more encouraging frameworks in neurosurgical robotics, integrating brain surgical robots being used and being advanced. The reason for this paper is twofold, to address the most encouraging models for neurosurgical applications, and to examine a portion of the entanglements of robotic neurosurgery given the exceptional framework of the brain. The utilization of robotic assistance and input direction on surgical operations could improve the specialization of the experts during the underlying period of the expectation to absorb information.

Keywords: Medical and Surgical Robots; Surgical Applications; Brain Surgery; Minimally Invasive

Abbreviations

FDA: Food and Drug Administration; APS: Automated Positioning System; ETV: Endoscopic Third Ventriculostomy; CT: Computed Tomography; DBS: Deep Brain Stimulation; Stereo Electroencephalography (SEEG).

Introduction

Robotic surgery or robot-assisted surgery enables specialists to perform numerous kinds of complex systems with more exactness, adaptability, and control than is conceivable with customary methods. Robotic surgery is typically connected with negligibly intrusive (minimally invasive) medical procedure, a methodology performed through minor entry points [13]. It is additionally once in a while utilized in certain customary open surgeries. Robotic surgery with the Da Vinci Surgical System was endorsed by the Food and Drug Administration (FDA) in 2000. The procedure has been quickly embraced by clinics in the United States and Europe for use in the treatment of a wide scope of conditions [5]. The most generally utilized clinical automated careful framework incorporates a robotic arm with careful instruments appended to them. The specialist controls

the arms while situated at a computer resource close to the surgical table. The support gives the specialist a top-quality, amplified, 3-D perspective on the careful site. The specialist leads other colleagues who help during the activity.

Just as manufacturers depend on robots to lessen human mistakes and keep up item quality, so too are surgical robots, lightening weakness while helping methodology requiring incredible accuracy [9]. The significant expense of surgical robots has been a boundary to selection; however more medical clinics are concluding that they're worth the venture. The equipment can assist specialists with performing minimally invasive operations, from which patients can recuperate more rapidly and effectively than customary systems [14]. The worldwide market for surgical robots will encounter a compound annual growth rate of 12.1%, from $4.5 billion in 2018 to $8.5 billion by 2023, as per Markets and Markets.

The University of Oxford has directed a preliminary of the Preceyes Surgical System. The test included 15 patients who required membranes removed from their eyes or had a development of blood beneath the retina because of age-related macular degeneration.

Half of the individuals got customary methodology, while the others got robotic surgical procedures [15]. Every one of the medical procedures was fruitful; however, the robotic surgical methodology was at any rate as fruitful and was now and then considerably more compelling than doing the procedures physically. In 2019, there are plans to utilize surgical robots to administer gene therapy to the retina [10].

One issue for people living in remote regions is gaining admittance to urgent therapeutic consideration, particularly with a lack of gifted specialists at the nearby medical clinic. Luckily, robotics with different advances, for example, virtual reality is helping specialists get ready. They can rehearse in the virtual world before there's a patient on the surgical table, which is useful for confounded methodology. Now and then, virtual reality with haptics to assist clients with getting material input that carries more authenticity to these training sessions. Notwithstanding, empowering specialist doctors to get on-site training, the Cor Path System from Corindus Vascular Robotics takes into consideration remote medical surgery [16]. The organization depicted it as the primary remote telerobotic interventional stage. In an ongoing case in Stanford, a cardiovascular specialist played out a 15-minute technique on a patient who was around 20 miles away. The specialist utilized the framework to embed a stent into the patient while working the robot from a remote place and checking the advancement on a screen. The Cor Path System relied upon fast Wi-Fi. Specialists holding on with the patient were accessible to step in inside around 30 seconds in the event of a blackout. Remotely controlled surgical robots could profit patients who are too sick to even consider being shipped to an area where a specialist is accessible [6]. The long advancement times, security necessities, and significant expenses of surgical robots have just prompted some consolidation. The above examples feature how surgical robots are making things conceivable that specialists likely didn't dream about a few decades prior. Indeed, even as quick as innovation is developing, specialists don't have to stress over robots assuming control over their employments. All things considered, even on account of the remote medical procedure referenced above, people are continually managing the surgical robots and indicating what moves they make. Their decision-making expertise is as yet basic to fruitful consideration [4].

Surgeons at Stanford Medical Center use robotic surgery for gynecologic procedures, prostate surgery, kidney surgery, gallbladder surgery, and other procedures. Since these procedures can now be performed through very small incisions, patients experience a number of benefits compared to open surgery, including:

1. Fewer traumas on the body such as surgical site infection.
2. Minimal scarring, less pain and blood loss.
3. Faster recovery time.

Materials and Methods

A few robotic elucidations have been created to address the particular difficulties related with mediations on the brain [17]. Deep pathology requiring control of or direct injury to the parenchyma has propelled gadgets which may limit harm to typical tissue. In spite of the fact that this isn't intended to fill in as a study of surgical robotics technology all in all, a comprehension of the subtypes of framework accessible is useful. Articulately an order dependent on the robot–surgeon collaboration was proposed [3]. Three frameworks are portrayed. The first is a supervisory-controlled robotic system in which the mechanical mediation is preplanned and customized and afterward regulated by the specialist as it completes its modified developments independently. The second is an automated tele surgical framework in which the robot is controlled by the

specialist continuously through remote control, with constrained input to the administrator. The third is a common control framework where the specialist straightforwardly controls the developments of the robot as the robot upgrades the specialist's aptitudes through expertise improvement, a term which for the most part portrays mechanical answers for human restrictions, including physiologic tremor decrease (Figure 1).

Figure 1: Medical Robot Performing Brain Surgery.

As effectively expressed, consideration has been centered on accessing deep pathology or structures, for example, the third ventricle with constrained injury to the typical brain. Coupling these gadgets, in this manner, with image based route frameworks and creating controlled, exact objective securing abilities have been critical advances in endeavoring intracranial techniques. When all is said in done, with these assets, existing models center their innovation on explicit errands [1].

Among the least complex and most broadly utilized supervisory-controlled robot is a specific move up to the Leksell Gamma Knife radio surgical framework. The Automated Positioning System (APS) will alter the patient's head inside a collimator naturally, in view of a foreordained stereotactic plan [2]. A few investigations have affirmed the advantages of such computerization, affirming shorter treatment times, decreased presentation of patients and work force to radiation, and more noteworthy capacity to convey radiation to an expanded number of littler isocenters, in this manner lessening the most extreme portion to theobjective.

The Neuro Mate framework was the principal FDA-endorsed automated gadget for robotic neurosurgery. Like Minerva which pursued, this framework includes an inactive mechanical arm which moves in a pre-modified course to a particular site characterized by coordinated neuronavigational frameworks for stereotactic biopsy or utilitarian neurosurgical applications [8]. The Minerva venture endeavored to represent brain by putting the mechanical arm inside a CT scanner to give ongoing image direction. Security issues constrained the end of this gadget. Signs for the Neuro Mate keep on extending as image direction innovation progresses [18]. Ongoing examinations have demonstrated its limitation and focusing on capacities are similar with those of standard confining frameworks. This framework accomplished a decent precision with a frameless application in microelectrode arrangement for treatment of Parkinson's infection. Evolution of Universal Robot Systems has been tried for a few neurosurgical applications. Pedicle screw positions and endoscope-helped transsphenoidal pituitary ademona resections, albeit effective, were esteemed by the individuals, endeavored these applications to be excessively unwieldy and tedious to legitimize their utilization. All the more as of late this framework has been utilized for endoscopic third ventriculostomy (ETV) in patients with hydrocephalus auxiliary to aqueductal stenosis. In particular, the mechanical arm was utilized to correctly and dependably direct an endoscope to envision the floor of the third ventricle [19]. The ventriculostomy was performed physically by the specialist through working directs in the endoscope, which was held inflexibly by the robot. Hypothetical points of interest of this framework over specialist alone ETV are accuracy focusing through image direction coupling and finesse improvement, which takes out smaller scale developments of a hand-held extension. Up to this point there is no proof supporting a clinical or result advantage of automated over manual ETV, in spite of the deliberate contrasts [12].

Past intercessions requiring a solitary instrument or endoscope-adjustment provisions, tele surgical robots with several arms for both variable instrumentation and endoscopy are right now accessible in different fortes (Figure 2). The Neurobot telerobotic edifice has been utilized effectively in complex techniques requiring concurrent withdrawal and dismemberment. Robot-assisted craniotomy is a NeuRobot used to resect shallow parts of an intraaxial tumor on a live human subject, referring to expertise upgrade as one of the potential points of interest. At University of Oxford, a few da Vinci frameworks are accessible for both clinical use and research commitments. It has become standard instrumentation for prostatectomy and other urological systems, and is FDA-endorsed for general and gynecologic medical procedure too [7]. Given its tremor decrease, movement scaling abilities, different working arms, and

licensed Endowrist innovation which empowers for full scope of movement at the instrument head equivalent with that of the human wrist, this appliances were tried at foundation for a few neurosurgical methodologies moreover. We would say with cadaveric preliminaries of start to finish ulnar nerve reanastomosis, lumbar discectomy, intradural spinal dismemberment, and complex intraventricular medical procedure, huge snags to brain applications still remain [20, 23].

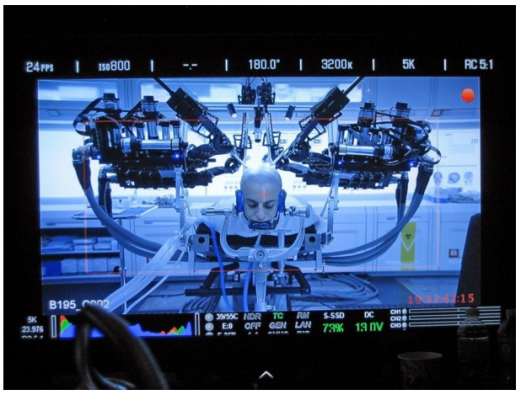

Figure 2: Brain Surgical Robot Featuring Several Robotic Arms.

These deterrents, be that as it may, do give knowledge into a portion of the necessities of automated neurosurgery, which require both programming and equipment changes. In particular, the conventional endoscope with working channels takes into consideration one tract through typical tissue to the ventricles instead of different tracts to suit instrumentation. This conventional model combined with Endowrist innovation may give the additional advantage of a more prominent scope of movement inside the ventricular framework, which is generally difficult to accomplish physically [21]. Brain surgical robots concentrated on exact restriction may likewise move, or be controlled, so as to unequivocally obtain an objective at a profound area to the detriment of typical tissue at a progressively shallow level. For instance, an endoscope situated mechanically to see the floor of the third ventricle may turn perilously at the cortex or foramen of Monroe and fornix. Docking after target procurement, in this manner, with proceeded with portability just distally is perfect [11]. At last, a reasonable inconvenience inside all classifications of Brain Surgical Robots is the absence of criticism to the administrator. Albeit visual criticism has improved fundamentally with progresses in optics and image direction, other tangible input is slacking. Position, speed, or quickening of the machines might be perceived through a mix of obvious signs and, for tele surgical or medical robot models, proprioceptive prompts [22]. Without complete tangible criticism, be that as it may, other huge sensations are lost, remembering power for contiguous edifices or qualities of controlled tissues, for instance consistence, surface, pulsatility, or elastisticy. Dynamic research in this part of brain surgical robot proceeds and will be vital in the reconciliation of these frameworks into neurosurgery given the ostensibly total need of such criticism while working inside the focal sensory system.

Results and Discussion

The first industrially accessible neurorobotic appliance for stereotactic neurosurgical systems was the Neuromate® stereotactic robot. This gadget can diminish method time and increment wellbeing in stereotactic neurosurgery in outline and frameless methodology. The robot has five degrees of opportunity, can be mounted with careful instruments and can be utilized in different methodology. Stereotactic neurosurgery is utilized by neurosurgeons to find careful focuses inside the brain. It utilizes 3D imaging information and either an outer casing or imaging markers appended to the scalp as reference focuses. This method empowers specialists to arrive at focuses on that are somewhere down in the brain in a negligibly intrusive way. Specialists would most usually utilize this method in systems including deep brain stimulation (DBS), stereo electroencephalography (SEEG), biopsy and endoscopy, or to convey gadgets or instruments to a little focus in the brain. It is currently utilized in numerous emergency clinics around the globe with a few introduced in the United Kingdom.

Specialists have utilized the neuromata in a huge number of terminal implantation methodologies for DBS, SEEG, neuroendoscopy and biopsies. On account of advances in medicinal IT, there is presently simple to utilize strategy arranging programming, for example, Renishaw'sneuroinspire™ for stereotactic systems. Addition of the product with the robot gives the specialist a framework where the adapted robot can be situated to empower the specialist to put gadgets into the right area. This is viable in diminishing human blunders and working time.

Late progress in robotic assistance in minimally invasive laser surgery denoted a stage forward in expanding the exactness, reproducibility, and straightforward mechanized moves in medical

procedure for glaucoma, and corneal transplant too. Integrated robotic assistance system with laser innovation for brain medical procedure detailed an expansion in productivity and a decrease in mistake. One of the difficulties to the far reaching acknowledgment of robotic technology in the neurosurgical working theater, when they have been demonstrated compelling and safe, is the capacity to prepare neurosurgeons to utilize the imaginative advancements. Reproduction systems are constantly improving and the more similar the recreation the better, as reenactment is a decent option in contrast to bodies. An advantage of a recreation is that it tends to be explicit to an individual patient whenever created utilizing preoperative imaging, so a specialist can get ready and practice an accurate patient-explicit technique utilizing the innovation as a dry run. Enhancements in augmented reality systems will demonstrate helpful in preparing specialists to utilize innovation of things to come.

Another upheaval positively influencing surgical training is live streaming. The main live gushed medical procedure was communicated in April 2016 to restorative stand-ins just as other invested individuals. Live streaming has broken topographical boundaries with the goal that accomplished specialists can exhibit careful strategies and systems continuously in real time. In the neurosurgical field advances will keep on improving velocity, material capacity and human-robot interfaces. Totally self-ruling medical procedure is as yet far off, however apply autonomy is as of now changing the substance of neurosurgery always, despite the fact that in a more slow, more dynamic path than the blast that influenced poor Phineas Gage. The below table depicts the merits and demerits of the recent brain surgical robot categories and their applications.

Surgical Robot	Category	Applications	Merit	Demerit
Neuro Mate	Supervised	Surgery	Exactitude	Expensive
Cyberknife	Supervised	Radiosurgery	Exactitude	Scant Functions
Minerva	Supervised	Surgery	Exactitude	Safety Disputes
Universal Robot Systems	Collective Control	Pedicle Screws, ETV, Transsphenoidal	Agility Amelioration	Absence Of Corporeal View
NeuRobot	Telesurgical	Tumor Resection	Agility Amelioration	Denunciation

Table 1: Brain Surgical Robot Category and Applications.

Conclusion

Surgical robots have obviously influenced the act of neurosurgery through a few FDA- endorsed gadgets, most eminently in the domain of radiosurgery. It is clear, nonetheless, that while the field of medical surgical robot technology progresses, and consideration must be given to the subtleties of brain medical procedure and careful life structures. Incorporations of new engaged innovations at that point can be adjusted all the more effectively into the neurosurgeons as of now exceptionally specific working condition. Making the fortune of robotization, and tangible criticism, is of most incentive to medical surgical technology in the event that it very well may be examined with regards to every claim to fame. The robots most generally utilized in neurosurgery have been results of this relevant research, which focused on focal sensory system explicit arrangements. Endeavors to adjust other instrumentation for neurosurgical use have demonstrated to be less powerful.

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Bibliography

1. PS Jagadeesh Kumar., *et al.* "Robotic Simulation of Human Brain Using Convolutional Deep Belief Networks". *International Journal of Intelligent Machines and Robotics* 1.2 (2018): 180-191.

2. C Stu., *et al.* "Robotic technology in spine surgery: current applications and future developments". *Intraoperative Imaging* 109 (2011): 241-245.

3. S Badaan and D Stoianovici. "Robotic systems: past, present, and future," Robotics in Genitourinary Surgery, Springer, New York, NY, USA (2011): 655-665.

4. PS Jagadeesh Kumar., *et al.* "Deep Robotics and Medical Applications". Baker and Taylor Publisher Services, North Carolina, United States (2019).

5. Singh I. "Robotics in urological surgery: review of current status and maneuverability, and comparison of robot-assisted and traditional laparoscopy". *Computer Aided Surgery* 16.1 (2011): 38-45.

6. GP Moustris., *et al.* "Evolution of autonomous and semi-autonomous robotic surgical systems: a review of the literature". *International Journal of Medical Robotics and Computer Assisted Surgery* 7.4 (2011): 375-392.

7. PS Jagadeesh Kumar., *et al.* "Deep Robotics in Computational Neuroscience and Human Brain Behavior". The World Congress on Engineering and Computer Science (WCECS'18) Proceedings of International Conference on Intelligent Automation and Robotics (ICIAR'18) San Francisco, USA (2018): 66-71.

8. B Challacombe and D Stoianovici. "The basic science of robotic surgery". *Urologic Robotic Surgery in Clinical Practice* (2009): 1-23.

9. H Kenngott., *et al.* "Status of robotic assistance: a less traumatic and more accurate minimally invasive surgery?" *Langenbeck's Archives of Surgery* 397.3 (2012): 1-9.

10. P Gomes. "Surgical robotics: reviewing the past, analysing the present, imagining the future". *Robotics and Computer-Integrated Manufacturing* 27.2 (2011): 261-266.

11. L Guo., *et al.* "A survey on the gastrointestinal capsule microrobot based on wireless and optoelectronic technology". *Journal of Nanoelectronics and Optoelectronics* 7.2 (2012): 123-127.

12. A M Okamura., *et al.* "Medical and health-care robotics". *IEEE Robotics and Automation Magazine* 17.3 (2010): 26-37.

13. N Fragopanagos and JG Taylor. "Emotion recognition in human-computer interaction". *Neural Networks* 18.4 (2005): 389-405.

14. C Chelba., *et al.* "Retrieval and browsing of spoken content". IEEE Signal Process. Mag 25.3 (2008): 39-49.

15. F Biadsy. "Automatic dialect and accent recognition and its application to speech recognition," Ph.D. thesis, Graduate School Arts Sci., Columbia Univ., New York City, NY, USA (2011): 1-171.

16. T Bocklet., *et al.* "Age and gender recognition for telephone applications based on GMM supervectors and support vector machines". In Proc. IEEE Int. Conf. Acoust. Speech Signal Process (2008): 1605-1608.

17. MIA Shahin. "Gender-dependent emotion recognition based on HMMs and SPHMMs". *International Journal of Speech Technology* 16.2 (2013): 133-141.

18. O Abdel-Hamid., *et al.* "Applying convolutional neural networks concepts to hybrid NN-HMM model for speech recognition," In Proc. IEEE Int. Conf. Acoust., Speech Signal Process (2012): 4277-4280.

19. P Domingos. "A few useful things to know about machine learning". Commun. ACM 55.10 (2012): 78-87.

20. JT Senders., *et al.* "An introduction and overview of machine learning in neurosurgical care". *Acta Neurochirurgica* 160.1 (2018): 29-38.

21. LC Resende., *et al.* "Support vector machine application in composite reliability assessment". In Proc. 18th Int. Conf. Intell. Syst. Appl. Power Syst. (ISAP), Porto, Portugal (2015).

22. C Fredouille., *et al.* "Application of Automatic Speaker Recognition techniques to pathological voice assessment (dysphonia)". In Proc. Eur. Conf. Speech Commun. Technol. (Eurospeech) (2005): 149-152.

23. R Sutton and A Barto. "Reinforcement Learning: An Introduction," Cambridge, MA, USA: MIT Press, Second Edition (2019).