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Use of Medical Robots in Allowing Surgeons to More Dexterous Manipulate Surgical Instruments or Catheters Inside the Patient's Body During Minimally Invasive Surgeries

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Abstract

Robots are used in surgery to improve the entire surgery process. Most surgery robots are able to do open surgery and have different kinds of benefits such as shorter hospitalization, quick recovery, reduction of pain, little incision, less possibility of infection, minimal blood loss and minimum scarring. Surgery robots are able to do fast surgery and as a result the patients recover quickly. Surgical robots have been developed to overcome the surgical limitations [1]. Long time hospitalization is not needed for the patient's surgery by robots. Mostly the patients return to normal conditions quickly due to fast surgery and for this reason short hospitalization is possible in robot surgery. Currently robots are used to do surgery and mostly medical experts control the robots to do surgery with robots. Robotics technology has improved and the development has helped to make surgical robots in the field of medical care. Surgical robots have a long history in the medical field. This kind of robot was started to be used in the medical field in the year 1985 with the Puma 560. Stanford Research Institute has started research on developing robots which have surgical senses that can help to do various critical surgeries.

Keywords

Catheters, Invasive, Robots, Surgeons, Surgery robots.

INTRODUCTION

Technology is developing and with this development the usability of technology has increased. Robots are a vital technology and with the development of technology capability of robots has been improved. In the early stages, robots have been used mainly in industrial activities such as logistics and manufacturing. In the present time, advanced level of robots helps to improve its usability and usages of robots is increasing in the medical sector.

Several human surgeons and medical experts have joined with this research to develop advanced surgical robots. In the current situation various surgical robots are used in medical care to do surgeries for patients. In many cases the robots are capable of doing critical surgeries. Two arms have been developed in the robots and medical experts control the two arms during surgery. Different kinds of modern applications are installed in the robots that help to increase capability of the robots in surgery. ROBODOC and Prodoc these systems are installed in surgical robots and for this reason the robotics system is improved to provide commercial benefit. These commercially developed robots have gotten permission from the FDA to use these in surgery. The proposed study is to be developed on use of robots in surgery and capability of the robots in manipulating surgery instruments are to be described widely.

LITERATURE REVIEW

Benefits of using surgery robots

Economically short hospitalization is beneficial for both hospital and patients. The benefit helps to consider robot surgery in the medical field. Robots are capable of doing smooth surgery and for this reason in most cases patients do not feel much pain. On the other hand, pain to patients increases discomfort and smooth surgery by robots maintains comfort during surgery.

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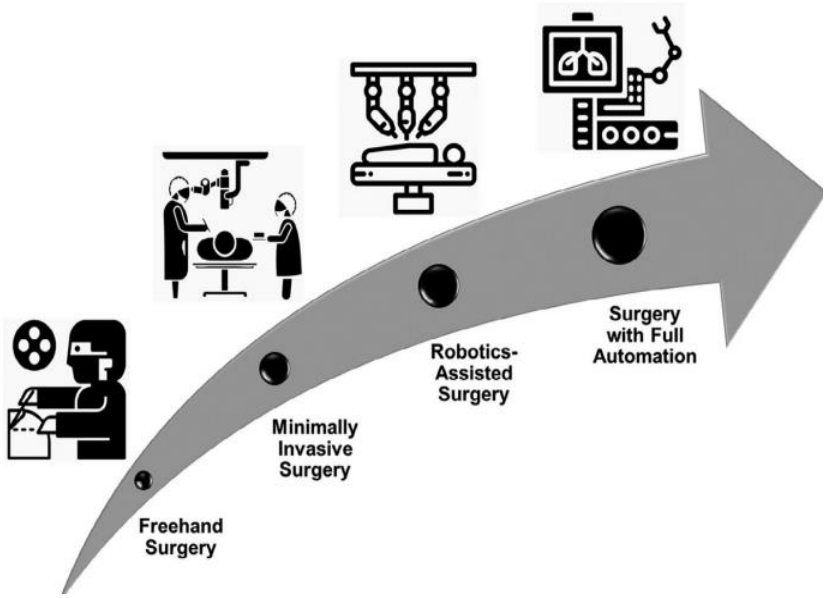

Figure 1: History of surgery
(Source: [1])

Accuracy of robots is much better than humans and in surgery robots can do surgery with small incisions and the possibility of infection is reduced due to small incisions. High blood loss is the important reason for mortality of patients [2]. Minimum incision plays an important role to reduce blood losses and robots are capable of doing minimum incisions. Minimum scarring occurs due to robotics surgery and for this reason robots are considered in surgery mostly. Advanced applications have been installed in robots and for this reason robotics surgery is more advanced as compared to human surgeons. The robots are able to do surgery with minimally invasive and human surgeons use robots in the surgery procedure. Robots have the ability of high degree dexterity and this development of robots helps to do surgery in tight spaces.

In traditional surgery long incision is done during surgery and the patients can be affected by infection due to long incision. These kinds of capabilities of robots encourage humans to consider robotic surgery in various cases. Robots are controlled by computer programs and for this reason experts can use these making accurate positioning in the human body for surgery. Accurate positioning plays a significant role to do small incisions in the human body during surgery and also surgery in tight space is possible due to accurate positioning [1]. These advantages help medical experts to do complex surgery and for this reason in most cases robotics surgery is considered for patients. Surgeons play the role of computer operator during surgery by robots. The medical experts control the instruments through computer programs and the robots do surgery as per the commands of computer programs.

Through the computer control medical experts can make surgery through tiny incisions and for this reason the possibility of infection is reduced. 3D cameras are attached with surgery robots and for this reason medical experts get clear visuals of the incision that helps to do the accurate surgery [3]. This kind of visual helps to do surgery accurately and in most cases medical experts use robotic surgery to avoid the risk factors during surgery. In robotics surgery surgeon's hands and fingers are controlled by computer transmitters that help to do the surgery properly. movement of fingers is controlled by the computer console and for this reason the possibility of risks is reduced. Minimum surgery instruments are used in robotics surgery as medical robots are able to do surgery with minimum surgery instruments.

Usages of minimum instruments help to make small incisions in the body and for this reason the possibility of large-scale infection in the body from the incision is decreased. Risks for infection are reduced and for this reason mostly the patients recover quickly and in a short time the patients can get back to their normal life. These benefits encourage both patients and medical experts for approaching robotics surgery. Technology is developing and for this reason more advanced features are to be installed in robots that enhance capabilities of it. Usages of robots are emerging [4]. This kind of development helps to bring betterment to robotics surgery to perform in much more complex surgery.

Current applications and opportunities of future in robotics surgery

Minimum incision is possible through robotics surgery and in this process, instruments are inserted in the body and minimum areas of the body are covered through the process. Various instruments are used to do minimum incision during surgery [5]. The entire minimum incision surgical instruments are classified into two divisions such as streetable and rigid. In most of the cases rigid instruments are used in laparoscopy surgery and these kinds of instruments are able to make small incisions in the body and for this reason rigid instruments are used in surgery to make small

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incisions. On the other hand, steerable instruments are able to navigate the body through torturous ways. These kinds of instruments are highly flexible and for this reason the possibility of happening large incisions is reduced. Different kinds of beneficial results are obtained from small incisions and the benefits are such as reduction of blood loss, low risk of infection, reduction of surgical trauma and these benefits allow patients to recover quickly.

In the initial stages MIS surgery faced several issues and for this reason the entire surgery process is highly criticized in medical treatment. Lack of a confined workplace, poor availability of stereo vision, and hand eye cooperation were the drawbacks which happened with MIS in the early stages. Technology has improved and these issues are removed from this surgery procedure. High quality 3D cameras are installed in robots that help to get clear visuals of surgery and for this reason the medical experts can do surgery with robots smoothly [6]. Dexterity is one of the important qualities of MIS surgery and the RAS approach has been introduced in the robotics system to ensure dexterity during surgery. Introduction of this approach helps to make an accurate position in the body during surgery that plays an important role to make small incisions in the body.

Accurate positioning has a great role to make accurate surgical outcomes and that is the reason for approaching the RAS model in MIS surgery. Different kinds of shaped robots are developed as per requirements in MIS surgery. Snake and DOFs like surgery robots are developed to improve its capabilities in surgery [7]. These kinds of robots are able to monitor incision three dimensionally that helps to explore the surgery with better accuracy. Snake shaped robots are deployed in surgery as the robots are highly fertile and on the other hand, these have great performance in MIS surgery. Special categories of mechanisms are used in the robots and for this reason most of the robots are soft that provides additional safety to patients from occurring infection during surgery.

CDMs have been installed in surgery robots that play an important role for providing light weight structure to these robots. This kind of structure helps to control the entire system easily and the whole surgery process is done smoothly. Different kinds of designs are provided to surgery robots to provide them flexibility in using during surgery. AU design, tube design are important designs used to develop robots for surgery [7]. Tube design is much more beneficial to control at the time of surgery. In the curve these designed robots are easily maneuvered and the possibility of infection is minimal. However, material development helps to provide more flexibility to the tube design robots and as a result possibility of damage to the body by robots is decreased. These advantages motivate the increased usability of tube designed robots for surgery.

Figure 2: Tube surgical robots
(Source: [7])

CTRa are used in navigation in the internal parts of the body that helps with positioning in surgery. Different kinds of control strategies are used in CTR robots to improve its ability in MIS surgery. Positioning control, path planning are the control strategies which are used in robots. Torque sensors are deployed in CTR robots to maintain accuracy for positioning [8]. On the other hand, collisions are avoided in tissues such as nerves, vessels and brain structure. Path planning is done by the CTR designed robots to avoid collision in these tissues. Better safety is provided by this planning in the surgery to improve its surgery capability. Worldwide optimal path planning strategy has been developed to provide this safety.

METHODOLOGY

Research methodology is considered as a systematic plan which is used to choose data collection method and data analysis method. Justification to choose the specific data collection and data analysis method is provided by methodology. Primary and secondary both data collection methods are present in research methodology. Primary data is collected from interviews and surveys [9]. Human participants are approached for interviews and surveys. Responses are directly collected from the invited participants based on various questions related to study. In the entire process of doing interviews and surveys a lot of time is consumed and on the other hand huge amounts of budget is required to consider primary data collection. However, the possibility of bias issue is involved in primary data collection as human participants can be biased during data collection. This bias issue cannot provide accurate discussion and proper study outcomes are too affected. Considering the facts, most researchers ignore the primary data collection method.

In the study primary data collection method has not considered these disadvantages that for this reason interviews and surveys have not been conducted to collect data. Secondary data is collected from various sources of secondary data. Mostly article, journal, website, magazine, these secondary data sources are considered to collect required data for making proper discussion [10]. Structured

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and cleaned data is available in the sources of secondary qualitative data. Secondary qualitative data is used in previous studies and for this reason the possibility of fake data is minimal. Clean and structured data helps to make authentic discussion on study that plays an important role to make effective study outcomes. Wide range of data is available in the sources and that helps the researchers to collect data as per their requirements. However, a huge amount of data sources is also available in Google and Google scholar. Researchers have the opportunity to gather data from the sources as their choices.

Sources of secondary data are easily accessible in Google and Google scholar and for this reason researchers do not have to spend much more time on data collection. This benefit helps to decrease time consumption in making the entire study and for this reason the whole study can be developed within the proposed time. Human participants are not involved in secondary data collection methods and for this reason there is no possibility of being biased in data collection. Possibility of decreasing effectiveness of study outcomes due to bias issues is not present in secondary data collection. Various data sources are available under secondary qualitative data collection methods and this flexibility helps to choose data sources as per the needs of researchers [11]. This kind of flexibility is provided in secondary data collection and mostly researchers consider this data collection for this reason. Most articles and journals are freely available in Google scholar and Google and researchers do not need much more financial support to collect data from these sources.

Economically collecting data from articles and journals is beneficial. Secondary qualitative data is available in the sources from different kinds of point of view that help researchers to consider required data or information to make discussion on proposed research topics. Online articles and journals have been approached to collect data for this study. Journal related to surgical robots have been considered by Google scholar and Google. Required information related to surgical robots has been gathered from the considered journal and article. More dexterity is essential for the surgical robots to improve their capabilities in surgery as compared to human medical experts [12]. Information related to this fact is necessary to make proper discussion on it. Various journals and articles have been searched in Google scholar and Google to collect information related to it. Wide discussion over the study topic is necessary to make proper conclusions on this topic. Conditions of surgery robots in the initial stages have been described over the study.

Journals and articles in which information related to initial conditions of surgery robots has been considered for this study. Necessary information from the journal and article has been gathered for doing wide discussion on it. Using surgical robots is beneficial for the patients. In most cases patients get several advantages from surgery robots. Google scholar and Google are used to collect data [13]. Several articles from Google have been approached and information related to using surgery robots is beneficial has been collected from the articles. The information helps to discuss the benefits widely in the discussion part that plays an important role to make proper conclusions. Limitations and challenges are faced by scientists in the way of developing surgery robots in the medical treatment field. Several journals from Google scholar have been considered to collect information related to it. The information has been used to describe the impact of the challenges and limitations on developing surgery robots in the medical field.

DISCUSSION

In recent time significant development has been noticed on robots' solutions basically in invasive surgery. Various robots are developed and deployed to do MIS surgery and in the current situation, surgery robots have been established as important clinical tools in modern media treatment. For example, in recent times several studies show that intuitive surgery is successful and the surgical system, da Vinci, is considered one of the successful examples of intuitive surgery [14]. Most rigid surgical instruments-based robots have been developed in the third industrial revolution. Mostly these robots were used in the manufacturing industry and technology is developing various advanced applications and features have been installed in robots and for this reason robot systems have been developed to do better surgery. In the initial stages, hand held robots were developed and traditional instruments were used in these robots at the time of surgery.

Both cardiac surgeons and cardiologists can benefit from the time savings provided by medical robots while doing endoscopic or catheter-based cardiovascular procedures. Using medical robots allows for more accurate and precise minimally invasive operations. During robotic surgeries, doctors can control surgical equipment with the same ease as in video games by using joysticks or telemanipulators.

One or more robots by the patient's side (called slave robots) and one or more master manipulators, such as a set of joysticks, are typical components of a telerobotic system that is used in surgical robotics. Using the surgeon's own hand movements as input, the master manipulators send signals to the robots at the bedside, which then operate the miniature surgical instruments. Telepresence, which means "being there from afar," is often used to describe the perfect surgical setup (Minskey, 1980). Employing microscopic surgical instruments attached to the ends of robots at the bedside, surgeons using a telerobotic system termed a telepresence surgical system can operate on a patient as if their hands were physically within the patient's body. Using a telepresence surgical system, doctors can do procedures with the same freedom of movement as in open surgery. Any gadget used for remote surgery must have reliable haptic feedback and sufficient tip dexterity.

The tip dexterity of several surgical robots has been enhanced, including the da Vinci surgical system from Intuitive Surgical Inc. The da Vinci surgical system is

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capable of following the surgeon's hands as they move in any direction and in any plane. Transparent haptic feedback is not simple or inexpensive to integrate in the da Vinci and other similar surgical robotic systems. This is because there aren't any accurate small-force sensors that can be placed at the tip of the robot, and the high robot forces caused by inertia and joint friction (Mahvash and Okamura, 2007). A force sensor on a steady teleoperator controller would be helpless against these forces (Mahvash et al, 2008). As an added bonus, the robot's shaft is highly malleable, allowing it to be used in a wide array of surgical applications (Mahvash et al., 2008).

In this chapter, we'll talk about how haptics are implemented in robots for soft-tissue surgery with an aim on offering a complete consideration of the clinical setting, underlying technologies, and cutting-edge applications. Before moving on to more advanced topics, we review the fundamentals of haptics, using the human sensory system as a yardstick against which future advancements might be judged. Following a discussion of pressing clinical issues that the implementation of haptic technology may ameliorate, this chapter provides a contextual overview of the field by detailing the clinical context, including the surgical domains and procedures that are of particular importance to robotics. Next, we'll cover the groundwork for haptics, sensing, and feedback systems so that you can see where we've been from and where we're going. From there, we'll dive into an overview of haptics in surgical robots, touching on the most pivotal commercial systems and discussing cutting-edge advances in the field. The chapter concludes with a discussion of recent developments in this field and a focus on the remaining technological and clinical obstacles.

Most commercially available robots used in cardiothoracic procedures are either multilink arms or robotic catheters. Through a number of ports drilled into the patient's chest wall, the multilink arms can access the heart. The da Vinci Surgical System, developed by Intuitive Surgical, falls under this category. The da Vinci System provides surgeons with numerous benefits, including improved dexterity and enhanced three-dimensional (3D) vision. In the da Vinci system, two "master" arms control three or four "work" arms that are placed at the patient's side. A Da Vinci Surgical System can be found at (www.intuitivesurgical.com/products/da Vinci Surgical System/). Each patient-facing arm has a flexible tip that can grip in six different ways (DiMaio et al., 2010). Even though the Da Vinci system was first developed for cardiac procedures, it has now found widespread application in gynaecological and urological (prostatectomy) operations.

Robotic catheters are often inserted into the femoral vein as a means of reaching the beating heart. Two companies, Stereotaxis Inc. (www.stereotaxis.com/niobe) and Hansen Medical Inc. (www.hansenmedical.com) (Camarillo et al., 2008), make robotic systems that can accurately place, operate, and control catheters. Stereotaxis catheters have a magnetic tip and are guided by a magnetic field surrounding the patient, while Hansen Medical catheters are controlled by a large number of pull-wires connected to external motors. Hansen robotic catheters and stereotaxis catheters have been developed with atrial fibrillation and other electrophysiological uses in mind. They make catheter-based ablation within blood vessels and the heart considerably easier and quicker to perform.

Due to the da vinci system's various (up to seven) entry ports and the requirement for direct access to surgical targets from these entrance points, arm collisions are a real possibility. Current robotic catheters have the disadvantage of having weak and flimsy tips. In order to perform procedures like tissue penetration and suturing, the robotic catheter's tip needs to be stiff enough to give sufficient force to move tissue. These restrictions reduce the usefulness of robotic catheters. At present, hansen Medical Inc. stereotaxis devices and equipment are used to execute atrial ablations in the clinic, provided that the procedure does not need a great deal of physical pressure. When compared to standard minimally invasive or open surgeries, the expense of using one of these commercial robots is higher.

Technology has developed a lot and improved applications have been installed in surgery robots that have changed the usages of traditional surgery instruments. Curved jaws, graspers and needle holders have been developed and installed in surgery robots [15]. The technological development has provided flexibility and limitations have been reduced from surgery. Positioning has been improved and the advanced technology is able to make accurate positioning. Basically, accurate positioning is considered one of the most important facts in surgery. In several cases it is found that accurate positioning helps to extend lymphatic dissertation and it is considered as the improvement of cancer patients. Dexterity enhancement is the prime need for surgical instruments [16]. This kind of improvement helps to increase flexibility to surgical instruments and as a result robots' surgery can be more capable to reduce complexity in surgery. 3D cameras are installed in surgery robots and for this reason medical experts get clear visuals of the tissue and around it.

The visualization plays an important role to understand the current conditions and to define the essential plan for surgery. Physical damage risks were present in the initial stages of surgery robots' development due to hard robots. In the early stages, developing soft robots was the challenge for scientists. However, soft robots are capable of maintaining small incisions during surgery [17]. Most of the traditional robots were rigid and for this reason the robots were stiff. Soft robots have multiple advantages as compared to rigid robots. Safety during surgery is one of the prime priorities the surgeon needs to ensure safety for using robots in surgery. Soft robots are much more flexible as compared to rigid robots and this flexibility provides more safety to internal tissues as compared to rigid robots. Physical adaptability of soft robots is better than rigid robots. These characteristics of soft robots play an important role in decreasing the impact of collision that can occur between several tissues. Compliant

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materials are used in soft robots and it provides better level dexterity. High level dexterity helps to maintain small incisions in the body during surgery that helps to recover patients quickly.

REFERENCES

[1] Thai, M.T., Phan, P.T., Hoang, T.T., Wong, S., Lovell, N.H. and Do, T.N., 2020. Advanced intelligent systems for surgical robotics. *Advanced Intelligent Systems*, *2*(8), p.1900138.

[2] Du, X., Wu, L., Yan, H., Jiang, Z., Li, S., Li, W., Bai, Y., Wang, H., Cheng, Z., Kong, D. and Wang, L., 2021. Microchannelled alkylated chitosan sponge to treat noncompressible hemorrhages and facilitate wound healing. *Nature communications*, *12*(1), pp.1-16.

[3] Ly, P.T., Lucas, A., Pun, S.H., Dondzillo, A., Liu, C., Klug, A. and Lei, T.C., 2021. Robotic stereotaxic system based on 3D skull reconstruction to improve surgical accuracy and speed. *Journal of neuroscience methods*, *347*, p.108955.

[4] Wood, L.J., Zaraki, A., Robins, B. and Dautenhahn, K., 2021. Developing kaspar: a humanoid robot for children with autism. *International Journal of Social Robotics*, *13*(3), pp.491-508.

[5] PISLA, D., ANDRAS, I., VAIDA, C., CRISAN, N., ULINICI, I., BIRLESCU, I. and PLITEA, N., 2021. New approach to hybrid robotic system aplication in single incision laparoscopic surgery. *ACTA TECHNICA NAPOCENSIS-Series: APPLIED MATHEMATICS, MECHANICS, and ENGINEERING*, *64*(3).

[6] Attanasio, A., Scaglioni, B., De Momi, E., Fiorini, P. and Valdastri, P., 2021. Autonomy in surgical robotics. *Annual Review of Control, Robotics, and Autonomous Systems*, *4*, pp.651-679.

[7] Alfalahi, H., Renda, F. and Stefanini, C., 2020. Concentric tube robots for minimally invasive surgery: Current applications and future opportunities. *IEEE Transactions on Medical Robotics and Bionics*, *2*(3), pp.410-424.

[8] Ortega-Aranda, D., Jimenez-Vielma, J.F., Saha, B.N. and Lopez-Juarez, I., 2021. Dual-arm peg-in-hole assembly using DNN with double force/torque sensor. *Applied Sciences*, *11*(15), p.6970.

[9] Imlach, F., McKinlay, E., Middleton, L., Kennedy, J., Pledger, M., Russell, L., Churchward, M., Cumming, J. and McBride-Henry, K., 2020. Telehealth consultations in general practice during a pandemic lockdown: survey and interviews on patient experiences and preferences. *BMC family practice*, *21*(1), pp.1-14.

[10] Khiong, K., 2022. Impact and Challenges of Digital Marketing in Healthcare Industries during Digital Era and Covid-19 Pandemic. *Journal of Industrial Engineering & Management Research*, *3*(5), pp.112-118.

[11] Davidson, E., Edwards, R., Jamieson, L. and Weller, S., 2019. Big data, qualitative style: a breadth-and-depth method for working with large amounts of secondary qualitative data. *Quality & quantity*, *53*(1), pp.363-376.

[12] Boyraz, P., Dobrev, I., Fischer, G. and Popovic, M.B., 2019. Robotic surgery. *Biomecatronics, Academic Press*, pp.431-450.

[13] Martín-Martín, A., Thelwall, M., Orduna-Malea, E. and Delgado López-Cózar, E., 2021. Google Scholar, Microsoft Academic, Scopus, Dimensions, Web of Science, and OpenCitations' COCI: a multidisciplinary comparison of coverage via citations. *Scientometrics*, *126*(1), pp.871-906.

[14] Dawood, A.B., Fras, J., Aljaber, F., Mintz, Y., Arezzo, A., Godaba, H. and Althoefer, K., 2021. Fusing dexterity and perception for soft robot-assisted minimally invasive surgery: What we learnt from STIFF-FLOP. *Applied Sciences*, *11*(14), p.6586.

[15] Cao, L., Li, X., Phan, P.T., Tiong, A.M.H., Kaan, H.L., Liu, J., Lai, W., Huang, Y., Le, H.M., Miyasaka, M. and Ho, K.Y., 2020. Sewing up the wounds: a robotic suturing system for flexible endoscopy. *IEEE Robotics & Automation Magazine*, *27*(3), pp.45-54.

[16] Taylor, R.H., Simaan, N., Menciassi, A. and Yang, G.Z., 2022. Surgical robotics and computer-integrated interventional medicine. *Proceedings of the IEEE*, *110*(7), pp.823-834.

[17] Zhu, J., Lyu, L., Xu, Y., Liang, H., Zhang, X., Ding, H. and Wu, Z., 2021. Intelligent Soft Surgical Robots for Next-Generation Minimally Invasive Surgery. *Advanced Intelligent Systems*, *3*(5), p.2100011.