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Perspective article

Robotic surgery: A pending subject in oral and maxillofacial surgery

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"Robot" is a word derived from the Czech *robota* meaning slave labor and was first introduced in 1921 by Karel Capek in his satirical drama Rossum's Universals Robots in which robots performed banal work so that humans could enjoy more interesting things in life.

The application of robotics to surgery is not solely driven by this reason. While it intrigues us, it is undeniable that technology has significantly altered our work processes. Notably, robotic surgery has demonstrated its efficacy across various surgical fields since its initial application in Neurosurgery in 1988, where it was employed to assist in a brain biopsy.[1]

Specifically, the first use in head and neck surgery was reported in 2005 by McLeod and Melder for the removal of a vallecular cyst using transoral robotic surgery.[2] Already at that time, one of the limitations of this system was already noticeable: the reduced working space.

Maxillofacial surgeries have conventionally been performed with large incisions, because of the complicated anatomy and limited surgical space. Minimally invasive surgical technologies have evolved dramatically over the past two decades to preserve function, reduce postoperative morbidity, and improve quality of life and for that reason robot-assisted maxillofacial surgery has been growing in popularity.[3–5]

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Although a specific robot for head and neck surgery has not yet been developed, the new single-port (SP) robotic surgical architecture is considered the most suitable for head and neck surgery. In this configuration 3 fully articulating instruments and a flexible three-dimensional high-definition camera delivered through a 25-mm cannula. The single-port design permits greater access and maneuverability for the surgical assistant.[3]

Robotic surgery brings forth a paradigm shift in the field of medical interventions, offering a multitude of advantages that significantly enhance surgical procedures.

Magnified 3-dimensional visualization

The surgical space undergoes a remarkable transformation with magnified 3-dimensional visualization. Integrated cameras, often two or more, provide stereoscopic views that are 10–15 times magnified. This technological advancement offers surgeons an unprecedented view, enhancing precision and accuracy.

Breaking the limit of human hands

Robotic arms, integral to the system, are equipped with articulating surgical instruments. This incorporation extends the range of motion and increases degrees of freedom, overcoming the limitations imposed by human hands. Consequently, surgical procedures benefit from heightened stability and accuracy.

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Minimally invasive

Robotic surgery enables the removal of tumors through minimally invasive approaches, such as transoral and retroauricular methods.[6–8] This approach minimizes surgical complications and reduces functional damage, representing a significant stride towards patient-friendly interventions.

Economizing medical staff

The utilization of robotic surgery extends beyond the operating room. Through remote operation capabilities and real-time shared surgery facilitated by Internet and satellite technology, medical staff can collaborate and contribute to procedures from different locations. This not only enhances expertise utilization but also provides opportunities for training and knowledge exchange.

In essence, the integration of robotics in surgery not only revolutionizes the technical aspects of procedures but also contributes to minimizing invasiveness, improving precision, and optimizing the utilization of medical expertise.[9,10]

However, while robotic surgery has demonstrated notable advantages, there remain significant challenges and drawbacks that continue to pose hurdles for its widespread adoption.

Lack of tactile perception and proprioception

One critical limitation lies in the absence of tactile perception and proprioception. Traditional surgeons are accustomed to feeling the strength and resiliency of tissues directly, a sensory aspect that is currently unattainable with robotic systems.

Lack of haptic feedback

The deficiency in haptic feedback poses risks for delicate maneuvers, such as tying sutures.[3] Surgeons may be unaware of excess tension, potentially leading to suture breakage. The absence of tactile feedback can compromise the precision required in certain surgical tasks.

Lack of specific instruments for maxillofacial surgery

The current limited application of robotic surgery has impeded the development of specialized instruments for certain surgeries. In maxillofacial surgery, for instance, there is a dearth of electric bone saws and drills designed specifically for robotic-assisted procedures.

Steep learning curve

The integration of robotic surgery necessitates a gradual adaptation to new instruments and surgical techniques. This initial learning curve can extend the duration of surgeries, potentially diminishing surgeons' interest. Moreover, the absence of specific courses for maxillofacial robotic surgery and variations in accreditation and qualification standards across countries further complicate the learning process.

High cost and low efficiency

Cost considerations loom large in the realm of robotic surgery. The substantial expenses associated with acquiring, installing, and maintaining robotic systems, coupled with the ongoing costs of surgical supplies, contribute to a high overall expenditure. This financial burden can impede the efficiency and accessibility of robotic surgery, limiting its broader implementation in healthcare settings.

In conclusion, for robotic surgery to gain widespread acceptance in maxillofacial surgery, it is crucial to address the existing challenges. The application of robotic surgery in this field is still a pending subject.

These are the pending issues that we need to address to enable its implementation.

Specialization of robotic instruments for head and neck therapy

Recognizing the unique challenges posed by head and neck surgeries, there has been a focused effort to specialize robotic instruments for this specific domain. Tailoring tools to the intricacies of these procedures enhances precision and allows for more targeted and effective interventions.

Progressive miniaturization of components

The ongoing trend towards the miniaturization of robotic components is a notable stride in improving surgical capabilities. Smaller, more agile components facilitate access to intricate anatomical structures, enabling surgeons to navigate with greater ease and conduct minimally invasive procedures with enhanced precision.

Realization of haptic feedback

Overcoming a significant limitation, recent advancements have led to the realization of haptic feedback in robotic surgery. The integration of this tactile sensation allows surgeons to perceive the force exerted during procedures, providing a more immersive and accurate experience. This breakthrough contributes to improved control and precision in delicate surgical maneuvers.

Combining robotic surgery and virtual surgical planning

The synergy between robotic surgery and virtual surgical planning represents a paradigm shift in enhancing accuracy and efficiency. By leveraging advanced imaging and planning technologies, surgeons can meticulously plan procedures in a virtual environment before executing them with robotic assistance. This integration optimizes preoperative strategizing, ultimately leading to improved outcomes and reduced surgical complications.

These advancements collectively underscore the commitment to refining robotic surgery, particularly in the context of maxillofacial surgery. As the field continues to innovate, the convergence of specialized instruments, miniaturized components, haptic feedback, and virtual surgical planning promises to redefine the landscape of surgical interventions, offering new horizons for maxillofacial surgeons and improved outcomes for patients.

Declaration of competing interest

The authors have no conflicts of interest relevant to this article.

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