ORIGINAL

The latest achievements of operative surgery in the development of modern medicine and dentistry: challenges of implementing artificial intelligence

Los últimos logros de la cirugía operatoria en el desarrollo de la medicina y la odontología modernas: retos de la aplicación de la inteligencia artificial

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Abstract

Aim: to investigate the novel medical advancement in surgery. We also aim to investigate the various modern challenges of implementing artificial intelligence in medicine.
Methods: In our review, we involved English studies from common databases such as Web of Science, Scopus, Google Scholar, Pubmed, and the Cochrane Library using the following keywords "advancement", "artificial intelligence", "innovations in surgery", and "operative surgery" till November 2023.
Scientific novelty: There are published studies that have tried to determine the role of new technologies in the field of surgery; however, there is a lack of studies that have attempted to identify a comprehensive analysis of these innovations and their integration into healthcare services. In our article, we tried to evaluate the role of new technologies in modern medicine and dentistry, especially in the surgical field.
Conclusion: Newly advanced technologies have greatly benefited in developing overall healthcare services, especially in the surgical field. AI has several applications in the field of surgery, which has significantly impacted the current healthcare systems.

Key words: innovations in surgery, artificial intelligence, operative surgery.

Resumen

Objetivo: investigar los novedosos avances médicos en cirugía. También se pretende investigar los diversos retos modernos de la aplicación de la inteligencia artificial en medicina.
Métodos: En nuestra revisión, involucramos estudios en inglés de bases de datos comunes como Web of Science, Scopus, Google Scholar, Pubmed y Cochrane Library utilizando las siguientes palabras clave "avance", "inteligencia artificial", "innovaciones en cirugía" y "cirugía operatoria" hasta noviembre de 2023.
Novedad científica: Existen estudios publicados que han intentado determinar el papel de las nuevas tecnologías en el campo de la cirugía; sin embargo, faltan estudios que hayan intentado identificar un análisis exhaustivo de estas innovaciones y su integración en los servicios sanitarios. En nuestro artículo, intentamos evaluar el papel de las nuevas tecnologías en la medicina y la odontología modernas, especialmente en el ámbito quirúrgico.
Conclusiones: Las nuevas tecnologías avanzadas han contribuido en gran medida al desarrollo de los servicios sanitarios en general, especialmente en el ámbito quirúrgico. La IA tiene varias aplicaciones en el campo de la cirugía, lo que ha repercutido significativamente en los sistemas sanitarios actuales.

Palabras clave: innovaciones en cirugía, inteligencia artificial, cirugía.

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Introduction

Enhancing and strengthening healthcare services is considered one of the main and important goals for all societies worldwide. Because of recent technological advancements, healthcare services have seen major improvement over the previous several decades, from patient examination to recent advances in diagnostic and treatment modalities, including medical and surgical options[1,2]. The healthcare system provides medical services through an integrated strategy, including hospital facilities, medical professionals, and modern equipment[3]. Recent innovations and advancements in medical technology applications have provided the general population with higher-quality services, better care, and improved quality of life[4-6]. Among these advances, the innovations in 3D printing and nanotechnology have enabled the creation of customized implants and medication delivery systems. At the same time, wearable technology and telemedicine have enhanced the accessibility, ease, and customization of healthcare[7,8].

To implement the Future of Surgery Commission's recommendations, the Royal College of Surgeons of England is actively involved. The degree of complexity of the various medical interventions that aim to improve the overall patient's quality of life is one of the most important ongoing surgical issues worldwide[9]. Over time, there has been an increase in the demand for healthcare services, leading to general shortages of personnel and supplies in the medical system. To enable patients and even doctors to receive the best and most adequate healthcare services, this prompted interest in incorporating modern technological services into the medical systems[10]. Artificial intelligence (AI) plays an essential role in enhancing healthcare services in all aspects, from diagnosis to treatment involving operations improvement[11,12]. Recently, there has been evidence that AI can be beneficial in evaluating medical imaging, patient symptoms, and investigations from electronic medical records (EMRs). It can also correlate these factors to determine the disease's diagnosis and prognosis[13].

Research focus

In our review, we focused on studying innovations, recent advances in medicine, and integrating new technologies in surgery. We also investigate the roles and applications of artificial intelligence in operative surgery.

Research problem

There is a significant shortage in both healthcare facilities and providers. Therefore, there is increasing interest in integrating the novel technologies in surgery. There is fear that these advancements in medicine would replace physicians. However, others suggest that these innovations significantly impact the improvement of the healthcare services provided.

Research questions

1.What is the recent medical status?
2. What are the new advancements in medicine and surgery?
3. What is the role of artificial intelligence and recent technologies in operations?
4. What are the challenges of implementing artificial intelligence in the healthcare system?

Research aim

Our study aims to investigate the novel medical advancement in surgery. We also aim to investigate the various modern challenges of implementing artificial intelligence in medicine.

Literature review

The rapid progress of modern technology and research worldwide has aided in advancing medical care regarding how we diagnose, treat, and anticipate illness prognosis. It also increases our understanding of illnesses, leading to more personalized therapy[14]. These advancements have definitely benefited surgical practice, particularly in several aspects of surgery. However, there is still a need for increased awareness of these developments among physicians and academics globally, particularly in underdeveloped countries[15]. In the last ten years, remarkable advancement was achieved in global surgery, and serious and evidence-based national policies for scaling up surgical services worldwide are currently being formed[16]. Developing an accurate country-based assessment of the surgical disease burden, establishing an appropriate estimate of the current needs is an essential step in developing the healthcare service[17]. Recently, increased efforts have aimed to update and get the most benefits of modern medical technologies. This includes the use of modern machines, robots, and AI technologies in all medical aspects, including surgeries. There is fear that AI machines replace human clinicians. In 2018, a study investigating the role of AI in recent healthcare services showed that the most significant benefits of AI were shown in image analysis, virtual assistants, robotic-assisted operations, and clinical decision support[18].

Although there are fears that AI will replace human existence, according to a recent study that evaluated the potential for automation across various sectors, health, and education are the areas where robots are least likely to replace humans[19]. Clinical competence and the critical requirement for interaction with others will never, in all likelihood, render clinicians obsolete. Although AI will increasingly be utilized to solve specific repeated issues, most notably in the diagnosis process, it appears improbable that it will replace surgeons soon.

Robots

Nowadays, A surgical robot is capable of performing the whole surgical procedure independently. However, dealing with the unpredictable consequences of such operations is a very distant possibility. At the same time, Robots in the operating room are very intricate and sophisticated instruments used by surgeons and their teams, not replacements for human presence[20]. The high cost of robots remains a major challenge, but hospital networks, especially those with smaller facilities, have a good chance of working together to share this important resource. Regarding the remote surgery, China has already succeeded in this field, with a surgeon performing an entire operation on a patient thousands of miles away using remote robotic help over 5G networks. Although this remarkable achievement has not been utilized in most countries yet, augmented reality (AR) photographs utilization of to convey real-time information to specialized surgeons in another place seeking their advice to finish complicated surgeries is currently available in the UK[21].

Laparoscopy

Minimally invasive surgical techniques have become popular in practically all medical fields over the last 30 years. Laparoscopic surgery is one of the earliest and most commonly used minimally invasive procedures since the first laparoscopic surgery in gynecology in 1962[22]. It is believed that laparoscopic surgery is considered one of the greatest innovations and advances in the surgical field. It has resulted in a revolution in the employment of digital and robotic technologies in surgical practice. Compared to 'open' surgeries, it has significantly reduced patient recovery times. Even more remarkable, significant gains have been obtained while concurrently improving surgical quality[23]. Notably, a recent report published by Bingmer et al. revealed a significant 462% rise in laparoscopic patients performed by general surgeons over the last years, from 2000 to 2018[24]. Laparoscopic operations are significantly associated with fewer wound infections, less pain VAS score, shorter post-operative hospitalization, lower rates of morbidity and death, an earlier return to work, and an overall improvement in quality of life[25]. However, there were safety concerns when laparoscopy was first utilized. Fortunately, many of the first reported problems have become relatively rare as surgical teams have advanced past their learning curves over time[26]. New laparoscopic technologies are constantly being developed, primarily to improve patient clinical results and/or decrease costs. Laparoscopy has potential disadvantages, such as narrowing the operation visual field, limiting the tactile sensation, injuring the internal structures, and the major vessels, making it challenging[22]. **Figures 1** and **2** show the rise in proportion over the study period now taken up by laparoscopic procedures and the explosive rise of minimally invasive surgery and the progressive replacement of open technique, respectively.

Figure 1: illustrates the increase in the percentage of laparoscopic surgeries performed over the study period[27].

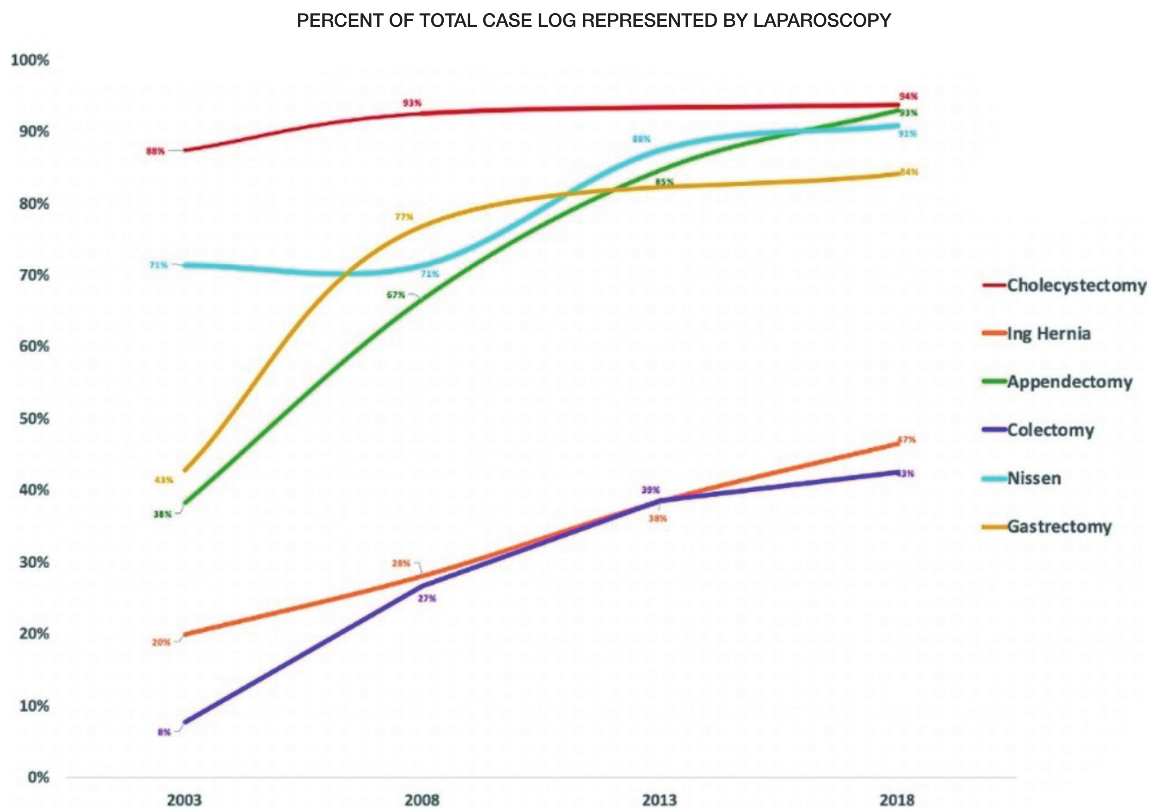
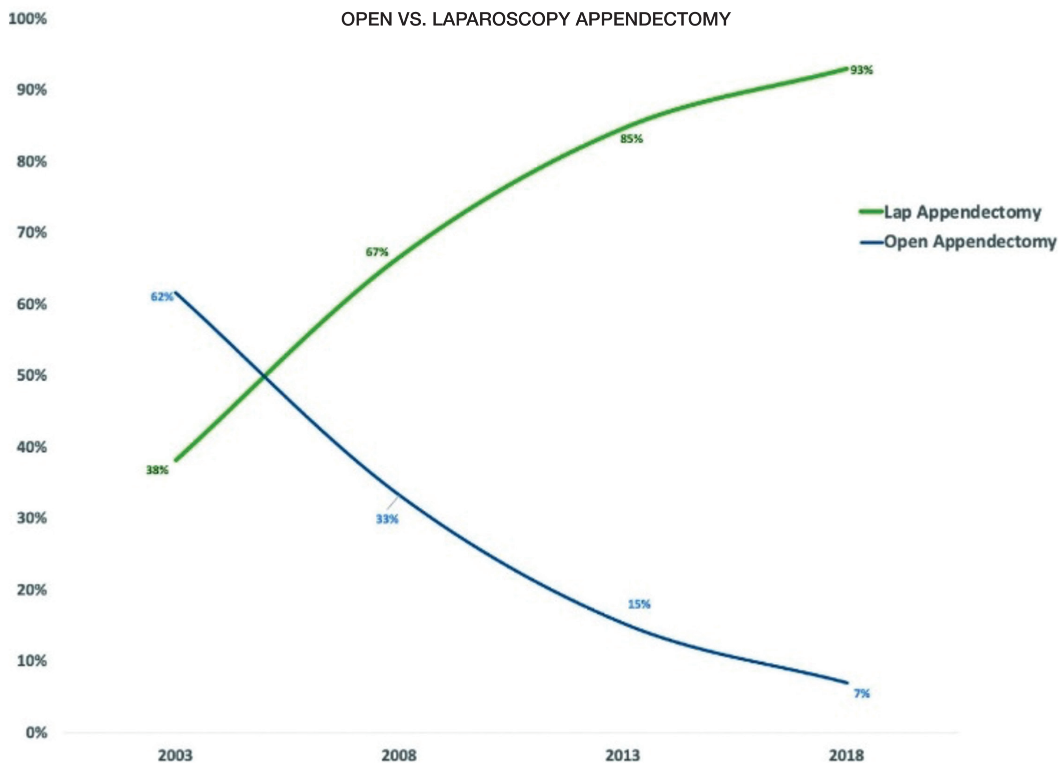


Figure 2: Illustrates how open operations are gradually being replaced with minimally invasive surgery, which is growing in popularity[27].



3D printing

3D printing is an additional innovation that has the potential to alter both surgical planning and the variety and efficacy of available implants. Data from patient imaging technologies may be extracted using 3D printing software, which can then be utilized to produce customized, custom surgical guides and implants that replace or stabilize diseased body parts or anatomical structures. It is anticipated that 3D planning and printing technologies will become extensively accessible, and the printed items will be sufficiently durable to be sent to all hospitals for local surgical teams to utilize. This technology may increase the safety and efficacy of surgeries in addition to providing the opportunity for surgical techniques that are now too difficult or yield poor results. Using this advanced technology, patients may have more options, higher expectations, and customized management. Giving patients access to 3D models might help them understand more about the medical procedures they are going to have, which would allow for more informed consent[28]. A Cross-Sectional Multispecialty Review in 2022 showed the advantages of 3D printing in planning complex medical procedures and training medical professionals. These advantages are improving understanding of the specific anatomy of each patient, simulation-based education and training, improved planning before surgery, mock simulated surgeries, creation of surgical guidelines, creation of implants customized for each patient, and bioprinted structures or organs[29].

Stem cells

Among the great advancements in medicine is the use of stem cells in various diseases. There are rapidly increasing efforts and research in the field of stem cell therapy. It is considered the only treatment option for certain disorders such as hemolytic anemias, leukemia, and bone marrow failure. It is also considered a reliable treatment option for other diseases. However, its utilization is still limited as major obstacles face us due to the hazards associated with a bad reaction between the donor and host cells. It has shown a promising effect in children with major disorders in the immune system in Great Ormond Street Hospital[30].

Ophthalmologists could make benefit from stem cell therapy in their surgeries. In the Academy of Medical Sciences, a fellow at Moorfields Eye Hospital, Prof Robin Ali, could use stem cell transplants to cure macular degeneration, which is usually a non-curable condition. Their results were promising, and they reported a significant vision improvement in the patients involved[30]. This raised the hope of treating the difficult retinal disorders. Moreover, Osaka University doctors in Japan restored the sight of a patient in one eye who used stem cell-derived corneal tissue to implant for the first time. To date, corneal transplantation from a dead person is the only available treatment option for severe corneal diseases. Living donors can provide transplantable cells. Rejection rates should also be far reduced since the stem cells mature to take on the features of the host body, unlike 20% of transplant recipients who reject their new cornea[31].

Artificial intelligence in the field of surgery

The definition of AI is the computational modeling of human cognitive functions, including self-learning, reasoning, and self-correction. These characteristics imply that AI has enormous potential for technologically progressing fields throughout all sectors of human civilization, as seen by the incorporation of this technology into the daily lives of people worldwide[32]. Exponential advancements in data storage, processing power, and data digitization have begun to transform medicine at a rate faster than human ability[33]. Pattern recognition is used in machine learning (ML), utilizing both supervised and unsupervised learning to predict outcomes. In contrast, deep learning (DL) has allowed AI to develop into image identification, processing, and bioinformatics learning[34]. Healthcare options combined with AI analysis, such as those described before, have the potential to improve patient care and reduce morbidity and mortality rates in emergency surgery through a variety of means, including diagnostics[35].

Materials and Methods

General background

The recent innovations and advancements in medical technology applications provided higher quality services, better care, and improved quality of life to the general population. Among these advances, innovations in 3D printing and nanotechnology have enabled the creation of customized implants and medication delivery systems, while wearable technology and telemedicine have enhanced the accessibility, ease, and customization of healthcare. AI plays an important role in enhancing healthcare services in all aspects, from diagnosis to treatment involving operations improvement. Recently, there has been evidence that AI can be very helpful in evaluating medical imaging, patient symptoms, and investigations. It can also correlate these factors to determine the disease's diagnosis and prognosis.

Recently, there have been increased efforts that aim to update and get the most benefits of modern technologies in medicine. This includes the use of modern machines, robots, and AI technologies in all medical aspects, including surgeries.

Inclusion criteria

1. All study designs of the articles were included, such as case series, randomized clinical trials, case-control, or systematic review.
2. We included studies evaluating the role of new technologies in the surgical field.
3. Most included studies should be recent, from 2018 to 2023.

Exclusion criteria

1. Studies and articles that were not peer-reviewed, as well as proposals, procedures, letters, and opinions.
2. Old studies that were conducted before 2010.
3. Studies unrelated to our topic or their aim were not related to ours.

Information sources

We utilized the following online databases: Web of Science, Scopus, Google Scholar, Pubmed, and the Cochrane Library using the following keywords "advancement", "artificial intelligence", "innovations in surgery", and "operative surgery" till November 2023. We collected studies using each set of keyword combinations to create an unbiased collection of publications. The references included in this paper were chosen because they are relevant to our topic.

Data collection

The included studies were reviewed following three stages. The first involved using EndNote Software to import the findings from electronic databases into a Microsoft Excel sheet. The articles entered into the Excel sheet were screened for titles and abstracts in the second stage. The third stage involved screening the included citations from Stage 2's full text. In addition, we manually checked the included publications' references for any potentially overlooked studies.

Statistical analysis

We conducted a qualitative study of the previously published studies. We could not do a quantitative analysis because our study is a narrative review. The outcomes that will be measured in the quantitative analysis must be specified, and more than two studies reporting data on these outcomes must be located and compared to draw a conclusion. We attempted a quantitative analysis in our research, but we could not identify specific results relevant to our subject or papers that presented similar data. To get strong evidence and current results and conclusions, we conducted a qualitative analysis of papers relevant to our topic, presented their findings, and compared them.

Results and discussion

Laparoscopic surgery (LS) and robotic surgery (RS) are used to perform various surgical procedures. RS is controlled like laparoscopic tools but with additional axial flexibility, fatigue resistance, repeatability, and stability[36,37]. The ultimate goal for RS would be autonomous AI instruments; they are now supervised, but with success: the Da Vinci system in prostatectomy, the Smart Tissue Autonomous Robot "STAR" robot that can stitch bowel. Robots are being developed for endoscopy to provide triangulation for suturing and knot tying[38,39]. The belief that robots cannot reproduce surgical competence is breaking down, with robots outperforming "expert" surgeons regarding consistency, spacing, time spent, and blunders[40].

In 2019, Lin et al. showed the role of AI and imaging in performing surgical procedures. This study reported using CT scans and AI to recreate the necrotic pancreatic regions in pancreatitis and assist drainage[41]. Similarly, the planning of difficult or complex procedures might be aided by AI models and imaging, as seen in orthognathic surgery, plastic, and reconstructive surgery. Knoops et al. created a model containing 4261 volunteer faces to identify and treat orthognathic patients[42]. Additionally, AI has been proposed for regeneration, including birth abnormalities. An autonomous device with feedback might enable non-invasive tissue restoration via mechanosimulation. A previous study utilized animals to generate new tissues. They are still working to develop implantable technologies that can restore tissue function[43].

AI has the potential to improve surgical education and learning as well. In certain instances, real-time feedback has been provided to surgeons, allowing them to modify the force they apply to delicate tissues. In addition to revolutionizing surgical learning, video recording makes it possible to identify surgical performance using AI[38,44]. An AI model with skin cancer diagnosis accuracy comparable to dermatologists was developed by Esteva et al.[45]. Using machine learning by Rajkomar et al. to predict hospital readmission rates and patient death may help medical personnel identify patients who require more care. Furthermore, Chung et al. developed an AI model that could predict when psychosis would start in those exhibiting clinical high-risk indicators[46]. A machine learning model was created by Khera et al. to identify individuals who are at a high risk of acquiring heart disease. This might lead to early intervention and preventative measures[47]. A previous review highlighted the recent application of AI in emergency surgery in both diagnosis and management and concluded that AI shows great potential in the field of emergency surgery. An ideal scenario would involve using AI to quickly and effectively refer suitable patients through the emergency department, identify surgical concerns on imaging, and even anticipate the risks of surgery based on the clinical history and vital sign observations, enabling a surgeon to provide a customized risk assessment for each patient. However, we should take into consideration that machines may give misleading information and wrong results and may worsen the overall outcomes[48].

Globally, surgical and non-surgical procedures for pediatric patients have shown rapid and significant advancement in recent years. Given the available data, pediatric surgeons must stay updated on the newest and greatest practices that yield the best results[49]. Injections of botulinum toxin were used to treat children with persistent constipation, according to a retrospective study conducted in the Netherlands. When preinjection pressure is more than 70 mmHg, botulinum toxin was shown to dramatically lower anal basal pressure. That being said, rectal washout is advised in cases of very increased anal basal pressure[50]. For patients with moderate to severe hereditary spherocytosis (HS), total splenectomy is the most successful therapy. One conservative procedure that can keep some of the spleen's function intact is partial splenic embolization (PSE). A single center's retrospective analysis included HS patients who underwent complete splenectomy and super-selective PSE (SPSE). They demonstrated that SPSE is safe and beneficial for moderate-to-severe pediatric HS; more extended follow-up periods and more patients are required, though[51]. Concerning recent surgical procedures in pediatric surgery patients, a previous case-series study reported the role of ArgyleTM Replogle Suction Catheter (RSC), endoscopic esophageal vacuum-assisted closure (EVAC) in treating patients with esophageal perforation (EP). They discovered that EVAC, which is frequently used to treat wounds and adult EP patients, was a viable treatment for pediatric EP. Additionally, they advised a quicker transition to RSC in order to minimize the need for anesthesia during later treatments. They found that the vast majority of patients[52].

Dental and orthodontist practices have changed significantly with the advancements in the modern technology, allowing them to treat patients in a more effective and efficient manner. Technology has altered the dental treatment process, making it more secure, patient-friendly, and more precise. 3D printing and digital X-rays are examples of these advances. In dentistry, technology is employed for purposes beyond diagnosis and treatment. Furthermore, it has reduced the cost and increased accessibility to dental treatment, especially for those with limited resources. Another technical development that has revolutionized dentistry is digital impressions. Dentists may now take digital images of a patient's dental arch using an intraoral scanner instead of unwieldy and painful analogical impressions. More exact and accurate impressions may be obtained due to this technology, which also decreases the need for follow-up visits and improves patient comfort. The authors of research published in this Special Issue examined the precision of four top intraoral scanners in full-arch digital implant impression[53]. Three-dimensional printing is another technical advancement that has significantly altered dental care. It has totally changed the way dentists create bridges, crowns, and other dental prosthetic restorations. With the use of 3D printing, dentists may create highly accurate models of a patient's teeth that they can use to plan and create specialized dental restorations. Implementing this technology results in dental restorations that take less time, increasing process efficiency and lowering costs[54]. Dental treatment is now safer and more efficient thanks to new technology, which has also improved patient results. Laser dentistry techniques are a good example of this. Gum reshaping, decay removal, and even root canal therapy are all possible with lasers. Patients may have less bleeding and discomfort because they are less intrusive than conventional dental instruments[55].

Limitations

The primary issue with this article is that it is a narrative review. The included research results are presented in written paragraphs in a narrative review. They don't undertake any pooled analysis using the data from the summarized studies. Real objectivity and pooled analysis are therefore precluded. A narrative review serves as a collated source of the most widely accepted views at the time of publishing. This may be useful to understand a body of evidence fully. As it does not thoroughly consider the alternative hypothesis, it does not guarantee that the prevailing ideas are true.

Conclusion

Innovative medical technology integration is of worldwide interest. Newly advanced technologies have shown a great beneficial role in developing overall healthcare services, especially in the surgical field. AI has several applications in the field of surgery, which has significantly impacted the current healthcare systems. We are facing challenges in the development of these enhancements and in implementing AI in modern medicine and dentistry. We should provide potential opportunities for new technologies to reach an improved comprehensive medical service.

Conflict of interest

All authors declare no conflict of interest.

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Ethical statement

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