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Original Research Article

Use of Virtual Reality in Surgery: Literature Review

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Abstract: ***Background***: Simulated reality, particularly virtual reality (VR), has gained prominence in surgical procedures over the past six years. This study systematically reviews the existing literature to assess the impact, benefits, and challenges of VR in surgery. ***Methods***: A comprehensive review of clinical research and experimental studies published in the last six years was conducted. Relevant studies were analyzed to identify key advancements, trends, and challenges in the implementation of VR in surgical practice. ***Results***: The findings indicate that VR significantly enhances surgical planning, training, and the assessment of surgeons' proficiency and technique. The technology demonstrates considerable potential in improving the effectiveness and safety of surgical procedures. However, major challenges remain, including the need to enhance the accuracy and reliability of VR technologies and the absence of standardized protocols for clinical implementation. ***Conclusion***: The literature review highlights the growing significance and potential of VR in surgical applications. While VR presents promising opportunities, further research is necessary to address technological limitations and establish standardized clinical guidelines to optimize its integration into surgical practice.

Keywords: Virtual Reality, Simulated Reality, Surgical Training, Surgical Planning, Clinical Application, Medical Simulation.

INTRODUCTION

Virtual reality, or VR, has emerged as a helpful tool, particularly in surgery and medicine. Virtual reality has been used in surgery much more frequently in recent years, and it has shown to be a valuable tool for increasing surgical proficiency and productivity. Virtual reality is also a helpful tool for improving surgical practice and training (Balci et al., 2022). In addition, augmented reality devices and mixed reality can be beneficial in medical training and in creating internal 3D models for surgery planning, simulating procedures for surgeon training, and displaying real-time clinical information during surgery. Several studies have shown that virtual reality can function with other technologies, including augmented and mixed reality. Although virtual reality surgery has made great strides, many important issues remain to be resolved (Bielsa, 2021).

One of these is clinical qualification; there aren't enough clear standards and guidelines for the clinical use of virtual technologies, and in-depth medical research is mandatory to estimate the effectiveness and security of virtual realities technology. The accuracy and reliability of virtual technologies also need to be improved. It is also crucial to remember that virtual reality is still in its infancy and that further study is required to determine its efficacy and safety in surgical procedures (Abbas et al., 2023). The literature on the use of simulated reality in operating procedures throughout the previous five years is systematically reviewed in this paper. The discipline's most important developments and trends were determined by analyzing pertinent clinical research and experiments published throughout this time. The literature assessment emphasizes the significance and promise of virtual reality in surgery and recommends future directions to enhance further its therapeutic application (Ghaednia et al., 2021).

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REVIEW OF LITERATURE

A guide for doing systematic reviews and meta-analyses in medical research is the PRISMA literature review. When doing a PRISMA-based literature analysis on the use of virtual reality (VR) in surgical procedures, the following factors need to be considered (di Lanzo et al., 2020):

- **Pose the question:** A precise and well-defined question needs to be posed regarding the use of simulated reality in surgical procedures throughout the previous five years.
- **Recognizing literary works:** One should conduct a thorough search of pertinent literature using electronic databases like Science Direct, Web of Science, PubMed, and MEDLINE.
- **Study selection:** Research should only be chosen if it satisfies the established inclusion and exclusion criteria.
- **Evaluation of study quality:** To ascertain a study's dependability, its quality should be evaluated.
- **Data extraction:** Information on the population, the intervention, the results, and the conclusions must all be taken from each study.
- **Data analysis:** The retrieved data should be examined to ascertain the degree and consistency of evidence used in surgical operations.
- **Results Presentation:** The literature review's findings should be brief and clearly stated, with tables and figures included.
- **Conclusions:** Succinct and unambiguous conclusions should be drawn considering the usage of virtual reality in surgical procedures during the last six years and its influence on training and planning for surgical procedures.

In summary, the PRISMA literature review is a thorough and methodical process that allows you to evaluate the available information regarding a specific topic (Thavarajasingam et al., 2022).

METHODS:

The systematic literature review technique is used for a quantitative, descriptive study. Using this method, you may locate, assess, and compile all of the evidence that is currently accessible for a particular subject. This method ensures objectivity and comprehensiveness in the search and evaluation of the literature by adhering to a strict and predetermined methodology (Pressman et al., 2024). In this instance, the review concentrates on the application of virtual reality to surgical procedures. The primary goal of the research being done by several authors is to conduct a comprehensive review of the literature covering the past 12 years, including systematic reviews, expert reviews, surveys, perspectives, and more. These studies have focused on developing virtual environments to assess different anatomical regions of the body for diagnosis, planning, and surgical training (James et al., 2022).

They have also explored using other technologies, such as augmented reality, to create 3D environments using semi-transparent glasses. In a different study, the authors examine the state of virtual reality in hip surgery, list its benefits, and discuss the benefits, drawbacks, and potential applications of various virtual reality techniques connected to the hip. Hip (like training and simulation) (Azofeifa et al., 2022). The main goal of the following study is to conduct a systematic review of the literature to gather current research on virtual realities and their use in surgery. This will provide an overview of the technology, benefits, and limitations of the results, as well as application strategies (Badiali et al., 2020).

TECHNIQUES AND STRATEGIES FOR GATHERING DATA:

The research question was first defined to gather data by determining the issue or subject to be studied. After that, essential works about the research question were found by searching the scientific databases related to the subject of the study, which, in this case, virus dual actual reality.

Table 1-Components Of Information Needed To Address The Research Questions

Table 1: Components of information needed to address the research questions	
Information components	**Questions to answer**
Application patterns	What virtual reality strategies were employed in the research that was conducted?
influence in the medical field	What effect does virtual reality have on surgical operation planning and execution?
Features of publications	What obstacles and restrictions apply to

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	virtual reality in surgical procedures?

Advanced searches with search strings containing the term "virtual reality surgery" were conducted in the databases above. The search parameters have been set to restrict the results to peer-reviewed papers published within the previous six years. This search term was chosen since it is a commonly used expression in scientific literature to refer to the application of virtual realities in the surgical area (Zhang et al., 2022). They examined English-language journals. To choose the papers that satisfied the inclusion requirements, a thorough examination of the identified articles' titles, abstracts, and keywords was conducted (see Table 2) (Ghaednia et al., 2021).

Table 2-Strings of Searches

Table 2: Strings of searches		
Database	**Applied chain**	**Results**
Web of Science	TO=(virtual reality surgery)	18
MEDLINE	("All Metadata": virtual reality surgery)	12

Six hundred fifty research articles were found, including records from other sources like PubMed, a free-access database that contains references to medical and scientific journal articles. The majority of the articles were systematic reviews, meta-analyses, and clinical studies, with a greater emphasis on healthcare professionals (Mozumder et al., 2022). Four hundred fifty hits came from the MEDLINE databases, and 200 hits from Web of Science. The PRISMA flow diagram (refer to Fig. 1) illustrates the methodology used to search, gather, and select articles. Relevant studies and studies that satisfied the predetermined inclusion and exclusion criteria were chosen (Hasan et al., 2021).

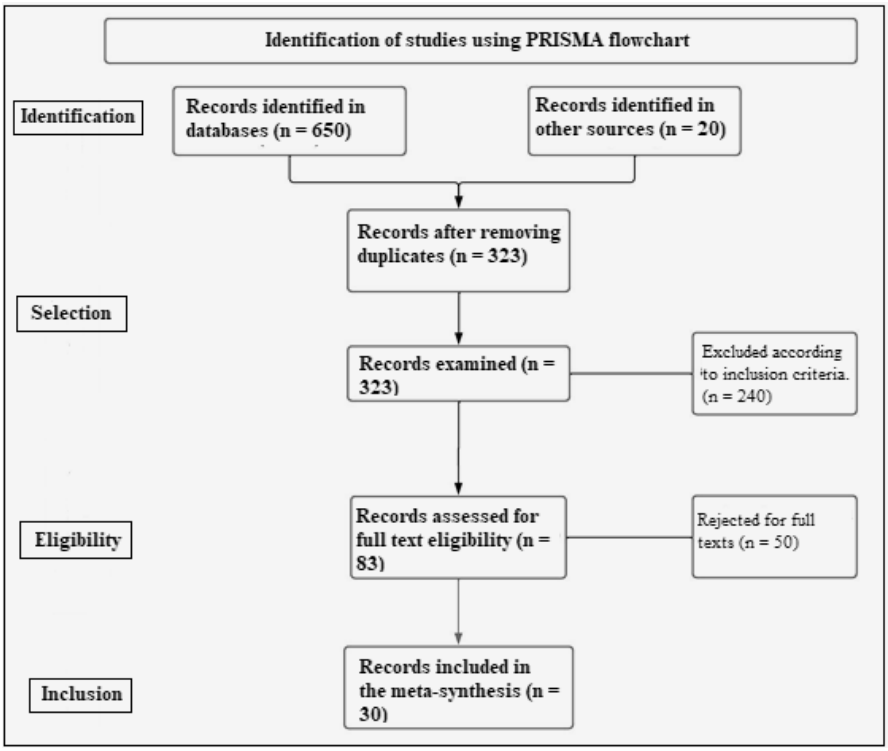

Figure 1 -A Flowchart of PRISMA

TECHNIQUES AND PROCEDURES FOR DATA ANALYSIS:

The chosen studies were subjected to quantitative analysis to gather accurate and unbiased data regarding the surgical

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application of virtual reality. Information was collected regarding advancements in surgical planning, accuracy, and medical professional skill sets (Brepohl & Leite, 2023). To determine whether virtual reality tools and procedures could enhance patient care and surgical outcomes, various preoperative and intraoperative virtual reality tools and techniques were assessed, and the outcomes were compared. Due to this quantitative analysis, Conclusions on virtual reality in surgery may become more precise and data-driven (Frederiksen et al., 2020).

RESULT:

Just 30 eligible research papers, 12 from MEDLINE and 18 from Web of Science were considered for review of this study, as indicated by the PRISMA flowchart, which depicts the study selection procedure. After collecting this information, each of the corresponding papers was categorized according to its unique qualities (Blanchard et al., 2022). Explains the effects that the usage of virtual reality has had in response to the question: "What is the impact of virtual realities on the planning and execution of surgical procedures?" the article discusses the influence that virtual reality use has had on surgical procedures, including the creation of novel instruments and surgeon training (Al-Hiyari & Jusoh, 2020).

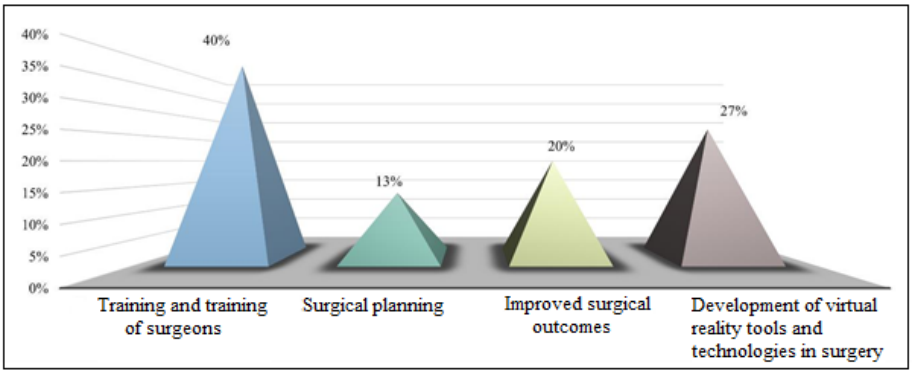

Figure 2-shows how virtual reality affects surgical techniques.

The development of virtual reality tools and technology has increased by 27%, while the improvement of results has increased by 40%. This represents the most significant impact that virtual reality has had in the previous five years on surgeon education and training (Alaniz et al., 2023). Surgical planning rises 13%, and surgical procedures approach 20% (see Fig. 2). Studies assessing the use of technology to teach and train surgeons during surgery demonstrate that the use of virtual realities in surgical procedures has significantly impacted their education and training(Kumar et al., 2024).

Conversely, several advancements in virtual reality technology have been applied to surgical procedures, and new technologies are constantly being created in this field (Ghaednia et al., 2021).

ln order to help surgeons better plan surgical procedures through the use of virtual reality systems, 3D simulations, and portable data gloves that integrate with other technologies like helper robots. Since surgical simulations are still not standardized, surgical planning has not had the same impact in virtual reality as in real life (Satapathy et al., 2023). This is because the primary goal of the studies is to assist surgeons in improving their knowledge and proficiency in the operating room (Taubin et al., 2023).

In response to the research question: What virtual reality methods were employed in the studies found? The methods or approaches used to apply virtual reality to surgical procedures are recognized (Ghaednia et al., 2021; Suresh et al., 2023).

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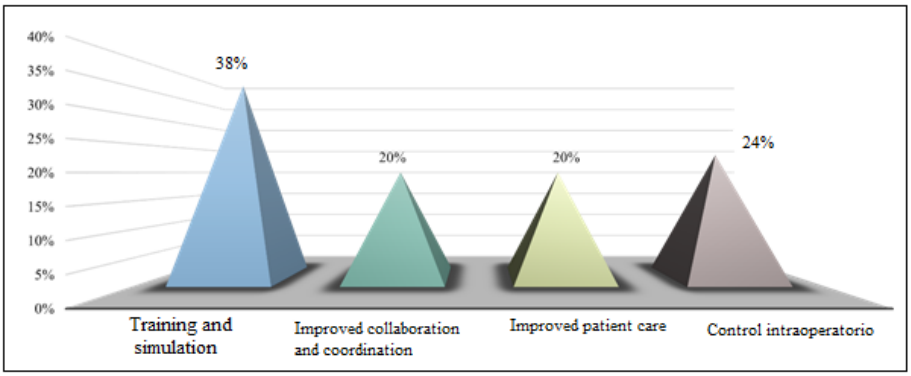

Figure 3-Techniques for using virtual reality

The most often employed strategy in the examined publications is training and simulation, with an incidence of 38%. Intraoperative control has a 24% incidence, while the enhancement of patient care and collaboration has a 20% incidence (refer to Fig. 3).

Most of the reviewed articles employ training and simulation techniques, such as the development of immersive virtual reality simulators, the employment of robots to provide improved support during assisted surgery, and the usage of simulators (Bargeri et al., 2023). This guarantees that surgeons who execute particular surgical duties get superior results. Additionally, a high percentage of intraoperative control is observed; this is also very beneficial to surgeons as it enhances precision and the sense of realism in simulators through tactile feedback (Williams et al., 2020).

Additionally, integrating different medical technologies with virtual reality helps improve the safety planning of surgical interventions. Although it didn't receive as much attention in this analysis, several articles still use this technique to assess collaboration and coordination amongst the surgical team (Mikhailenko et al., 2022). Examples include portable data gloves, a virtual reality platform in real-time, multi-user environments, and multiple VR simulation platforms spread across various locations connected by a network architecture (Ashfaq et al., 2025). Training the Surgeon enhances his abilities and dexterity during the procedure, which goes hand in hand with improving patient care (Lu et al., 2020).

Numerous studies demonstrate the use of various techniques, including virtual reality simulators, to help patients feel less pain. Interface with additional technology, including augmented reality or getting immediate feedback on how surgical tools should be positioned or oriented (Grassini, 2022). Regarding the study question: What obstacles and restrictions exist when using virtual reality during medical procedures? There are several obstacles and limitations in using virtual reality in medical procedures (Hong et al., 2021).

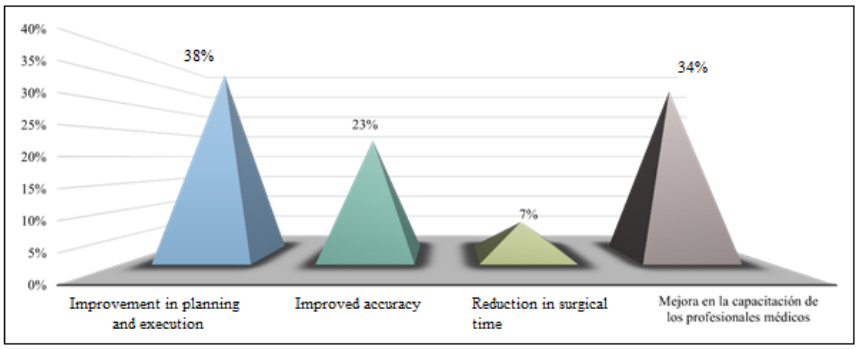

Figure 4-Difficulties with utilizing virtual reality

Enhancing planning and execution is the most significant issue in the examined publications, accounting for 38% of cases; other challenges include increasing medical professional training, which accounts for 34%, improving precision, which accounts for 23%, and cutting down on surgical time, which accounts for 23% (refer to Fig. 4). It is clear that one of the biggest obstacles to maximizing the use of virtual realities in surgical procedures is improving planning and execution (Urlings et al., 2022). Nevertheless, several authors have concluded that virtual reality can increase the accuracy and efficacy of surgical interventions by helping surgeons to properly plan and prepare for surgery, boost their confidence and skill, and inform patients about their condition and suggested course of treatment (Mandal & Ambade, 2022).

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Enhancing medical professional training is one of the issues examined in studies, where it is still necessary to make improvements for surgeons to become more skilled, even with collaborative settings or simulators. One of the obstacles to be addressed is increasing precision (Felszeghy et al., 2025). However, this can be done using haptic devices offering feedback on surgical processes. According to the papers reviewed, decreasing surgical times is still an issue that has to be addressed, although it should become less complicated as surgical planning improves (Sinha et al., 2023).

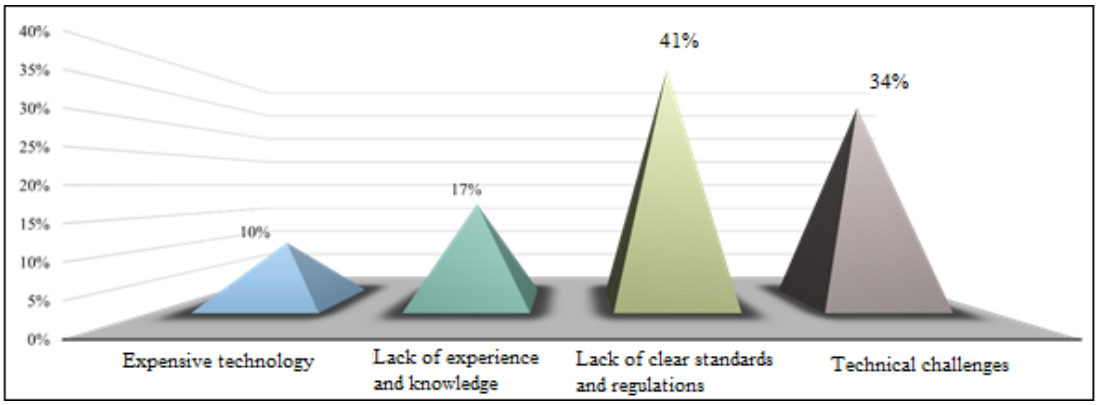

Figure 5-Virtual reality usage limitations

The investigation revealed several constraints, the most significant of which was the absence of clear rules and regulations (occurring 41% of the time) (Mo et al., 2022). Other limitations included technical difficulties (34%) and insufficient expertise and knowledge (17%). Costly technology represents 10% (Fig. 5). Since these are new technological implementations, there are currently no set clear standards for using these technologies in surgical operations, which was the primary constraint identified in the analysis. Several experts contend that although surgeons and patients favour virtual reality in surgical procedures, there are still no guidelines to guarantee that the technology is used appropriately (Danion et al., 2020).

The lack of clear standards and technical difficulties limit the use of virtual realities in surgical procedures. Future developments in virtual reality technology for surgical interventions are examined, including creating sophisticated visualization tools, robotic integration, and artificial intelligence (Oyewole et al., 2024). Since most applications are made using free software, pricey technology only covers a small portion of the development of these new technologies in healthcare, and a lack of expertise and knowledge can arise when developing these technologies. Developers should thoroughly understand surgical processes (Balla et al., 2023).

DISCUSSION:

Virtual reality has shown to be a promising technology for increasing planning and execution accuracy and efficiency during surgical procedures. This technology can also speed up patient recovery and lower the chance of problems (Bramhe & Pathak, 2022). However, virtual reality has its limitations when it comes to surgical practice. First, some clinics or institutions may be unable to afford the technology or the necessary equipment. In addition, more time and resources might be needed for the learning curve and training of medical staff. Another significant drawback is the lack of standardization in virtual reality systems (Liu et al., 2021).

Various systems' graphic quality, simulation accuracy, and usability can differ, affecting their applicability in surgical practice. Notwithstanding these drawbacks, virtual reality is still a valuable tool in surgical training (Buchner et al., 2022). As more sophisticated technologies are created and costs come down, their application will probably increase. To guarantee the safety and efficacy of virtual reality in surgical procedures, further research and assessment are necessary (Roessel et al., 2020).

CONCLUSION:

In conclusion, the precision, efficacy, and safety of surgical treatments could all be significantly increased by utilizing virtual realities. Surgeons can enhance their ability and skill and avoid errors and difficulties in actual surgery by practising in a virtual environment. Virtual reality can also be used for pre-procedural planning and practice before patient procedures. Virtual realities in surgical procedures are still limited and present several obstacles. There are several problems, such as the absence of guidelines for developing surgical simulations and virtual models and the necessity for medical staff to be adequately trained. Despite these obstacles, Virtual reality has a bright future in improving surgical procedures. This technology will probably keep developing and improving with time and additional research, enabling surgeons to do safer and more accurate surgeries on their patients.

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