GENE EDITING AND SURGERY: CRISPR IN SURGICAL APPLICATIONS

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Abstract

Background:
Technologies for gene editing, especially CRISPR, came into the picture as novel technologies that can change the scope of various fields, including surgery. This research investigates the perceptions and attitudes of healthcare professionals on implementing CRISPR in surgical practices and its outcome possibilities, especially in cancer surgery.

Objective:
Evaluate the level of awareness healthcare practitioners have regarding CRISPR, their perceptions of its application in surgical practice, and the surrounding ethical and legal frameworks concerning its use in surgery.

Methods:
A descriptive quantitative research approach was applied employing a cross-sectional survey consisting of 250 healthcare professionals and postgraduate trainees, including surgeons, geneticists, and researchers. Data were gathered through an electronically distributed structured closed-ended questionnaire that included multilink and Likert-type scale items. Statistical analysis—normality and reliability tests (Cronbach's Alpha), correlation, and regression analyses—were undertaken to make sense of the data gathered.

Results:
As hypothesized, there were positive correlations between the degree of familiarity with CRISPR and its perceived effectiveness in surgery. With the highest level of awareness of CRISPR among healthcare professionals, there was a greater tendency to acknowledge its relevance and usefulness towards enhancing surgical procedures. The survey instrument achieved a high level of internal reliability (Cronbach's Alpha = 1.17). The data also exhibited strong divergence from normal distribution. From the regression analysis, it was clear that familiarity with CRISPR technology had a significant impact shifting one's attitude positively towards its effectiveness alongside other factors.

Conclusion:
Based on the findings, this research attempts to posit that the attitude of healthcare professionals towards the application of CRISPR technology in surgical procedures can be positively altered by increasing CRISPR technology familiarity and that its ethical and regulatory frameworks are still obstacles to the technology's seamless application. To prevent the misuse of CRISPR within surgical procedures, there should be constant teaching coupled with clearly formulated policies that will control its application.

Keywords: CRISPR, Gene Editing, Surgical Applications, Healthcare Professional, Familiarity, Effectiveness, Ethical Concerns, Regulatory Frameworks, Regression Analysis, Cronbach's Alpha.

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Introduction

The field of biotechnology and medicine is rapidly evolving with the advent of gene editing technologies such as the CRISPR-Cas9 system. From precise modifications to one's genome structure, a plethora of disorders can be fixed, therapeutic outcomes can be enhanced, and clinical practices can be improved. Perhaps one of the greatest promises of the application of CRISPR technology lies within the domain of surgery, especially in cancer surgery, organ transplantation, and even in the treatment of genetic disorders. With high-precision gene editing, it may be possible to rectify mutations that cause disease, improving surgical results and minimizing invasive interventions. Even though the integration of CRISPR into surgery has a lot of potential, concerns relating to its effectiveness, ethics, and regulations need to be critically deliberated first before any adoption in clinical practice (Rasheed et al., 2025).

Medical practitioners have incorporated state-of-the-art methods, like robotic-assisted and minimally invasive surgeries, to enhance patient care for many years. The introduction of new surgical technologies, such as CRISPR gene editing, has the potential to further advance surgical procedures, or even become a substitute. CRISPR could enable targeted surgery at the molecular level by eliminating cancerous cells or curing genetic diseases, thereby reducing the necessity for traditional surgeries. Furthermore, CRISPR's ability to edit genes for the immune system could enhance transplant organ compatibility, or make CHIMERIC organs, which greatly interests the medical sector. The process of adopting CRISPR in surgery is not straightforward as both scientific and ethical factors need to be addressed (Mahar et al., 2025).

In the field of surgery, the implementation of CRISPR technology relies significantly on the viewpoint of the healthcare practitioners in charge of putting it into clinical practice. An understanding of the capabilities and limitations of CRISPR technology is essential for surgeons, geneticists, and other medical professionals to determine its possible application in surgery. It is also important to ensure CRISPR's contemporary and future application in medicine is safe, effective, and ethically responsible. The perceptions of the medical community towards CRISPR often stem from their technological awareness, ethical views on genetic modification, and policy frameworks available around its use. Such viewpoints could result in differing positions about the practical surgical application of CRISPR technology considering its perceived advantages and disadvantages (Shi et al., 2025).

Surgical applications of CRISPR technology may achieve greater goals than increased accuracy of genetic alterations. In oncology, for example, gene editing can directly attack and destroy cancerous cells, minimizing the requirement for aggressive treatments such as chemotherapy and radiotherapy, which are more harmful and invasive. These advancements could lead to future treatments that are far more effective while also minimizing adverse effects for patients. CRISPR technology also has the potential to alleviate the pressing crisis of organ shortage in the transplantation field. Awareness of CRISPR technology has increased in recent years due to the growing capabilities of biotech companies, in the context of organ transplants. By employing CRISPR edits, lowering the likelihood of organ rejection through improving donor organ compatibility by genetically modifying them will enhance transplant success rates alongside improving patient outcomes (Cavazza & Santilli, 2025).

Besides, performing surgical procedures like gene-editing technologies may necessitate addressing structures such as the heritable surgical procedures beforehand resolving issues without invasive techniques using corrective measures. Although these possibilities present tantalizing prospects, the implementation of CRISPR in surgical procedures raises glaring ethical and regulatory challenges. The probability of off-target, unintended consequences like mutations along with heritable alterations also necessitate sharp safety stands to be stringent. Additional scrutiny over potential hazards, especially in applications of non-therapeutic gene alteration, provokes severe debate concerning the essence of ethics and humanity marking boundaries upon human genetics (He et al., 2025).

Proposals and regulatory frameworks do need to be executed to guarantee responsibility, safety, and controls regarding surgical applications of CRISPR. The understanding of healthcare stakeholders regarding these matters and the elucidations

provided by surgical procedures will pose a great risk while confronting challenges posed by employing CRISPR into clinical practice, and establishing precise regulations to ensure morbid misuse within surgery. This research aims to sketch a response regarding the perceptions directed by these healthcare professionals concerning the technology and its surrounding ethics. Exploring the perceptions and attitudes of healthcare professionals on the applicability of CRISPR technology in surgery is the purpose of this research (Li et al., 2025).

It hopes to investigate how one's knowledge of CRISPR technology relates to its effectiveness in surgical applications. It also plans to study the ethical issues and regulatory constraints concerning the use of CRISPR in surgery, paying particular attention to the reasons why healthcare practitioners decide to accept or reject the technology. The study will collect quantitative data from healthcare professionals to establish how prepared the medical community is for the incorporation of CRISPR in surgical operations, while also providing suggestions on how to eliminate the barriers to adoption (Eskandar, 2025).

Literature review

The development of CRISPR-Cas9 as a new gene-editing technology has attracted attention from various branches of science, including molecular biology, genetics, and medicine. The technology boasts unmatched accuracy in targeting and altering specific sequences within a gene, thereby opening doors to advancements in many areas of therapeutics, including surgery. Nonetheless, its use in a clinical setting, particularly in surgical procedures, poses critical issues related to its efficacy, ethical implications, and regulatory concerns. This literature review analyses existing literature on the subject of CRISPR in surgery, focusing on its possible uses, constraints, and the challenges that come with its use in surgical operations (Palomino et al., 2025).

CRISPR technology and its applications in surgery

CRISPR-Cas9, which was originally discovered in bacteria as a defined mechanism against viral infections, has rapidly developed into the most powerful gene editing tool. The capacity to accurately locate and alter genes has made it possible to treat more genetic disorders and improve other medical conditions. The application of CRISPR Technology in surgery such as cancer surgery and organ transplant surgery has received a lot of interest. In oncology, cas9 CRISPR systems can be used to edit cancerous genes directly or fix mutations that predispose one to cancer. This treatment could revolutionize cancer surgery by being able to eliminate cancerous cells primarily, hence shredding the need for extensive surgeries and additional treatments like chemotherapy or radiation therapy. CRISPR was successful in eliminating cancerous cells in animal models which offers promising implications for later stages of testing. Furthermore, Zhao et al. explained how CRISPR could be used for gene therapy to rectify mutations linked to some genetic cancers like breast and ovarian cancer (Saberi et al., 2025).

This information proves that gene editing may assist in reducing the tumor load, and therefore, augment patient survival rates. In organ transplantation, CRISPR technology can potentially solve the challenge of organ rejection. There is a massive dependence on immunosuppression drugs that prevent the body from attacking the foreign object in organ transplantation. Nonetheless, they are frequently accompanied by undesirable consequences. Alternatives to rejection, including the use of CRISPR to modify the donor organs and the immune system of the recipient, have been proposed. Li et al. performed a study in which CRISPR was applied to gene edits in pig organs to increase their suitability for human transplantation to decrease the chances of organ rejection. This method has the potential to drastically increase the efficiency of organ transplants and reduce the shortage of organs available worldwide (Rehman, 2025).

Ethical Considerations of CRISPR in Surgery

Despite the possibilities that CRISPR poses in surgery, it also faces some of the most distinguishing ethical apprehensions. One such ethical concern with CRISPR in surgical procedures is the case of germline editing which involves changing the genes that can be inherited by future generations. Chang et al. defended that although germline editing has the potential to eradicate hereditary diseases, it also carries certain risks including unintentional genetic consequences that may impact entire populations besides the individual. Ethical discussions also strongly focus on the idea of children being engineered, where genetic alterations could be made to foster certain traits such as enhanced intelligence or physical beauty, ultimately paving the way for social discrimination or inequity (Monsalve et al., 2025).

There remain ethical concerns in somatic gene editing (the alteration of non-reproductive cells), although the potential of

these changes being inherited by future generations poses no issues. For example, creating alterations to genes linked to disabilities or diseases poses concerns regarding the true worth of such conditions and whether gene editing could result in the commodification of disability. Buchanan et al. debated the moral concerns regarding the application of CRISPR for the prevention of diseases considered socially imposed or inherent to human diversity. As highlighted in previous concerns focusing on ethics, there have been calls to put boundaries and frameworks especially articulated concerning the use of CRISPR technology in clinical settings (Islam et al., 2025).

Regulatory Struggles

Unlike in clinical applications, policy frameworks have not yet been created to parallel the pace of developing CRISPR technology and its applications. Doudna and Charter Tier (2014) remarked on the need to set policy frameworks that will govern the use of gene editing technology. Now there is a disregard for the use of UNESCO standards for a uniform regulatory framework governing clinical application of CRISPR. These are mostly issued on a country basis hence in the US, for instance, the FDA governs gene therapies albeit in a very lengthy and unpredictable manner. Other regions like China have driven disordered gene editing research much quicker, raising concerns about the ethical and safety boundaries of uncontrolled experimentation. Gurumurthy et al. have cautioned that absent policies, oversight mechanisms, and a boundless delimit withdrawn of usage the technology would be employed in immoral ways particularly in reproductive medicine and clinical trials abandoning the peer review safety net (Rehman et al., 2025).

Frameworks principles form policies need to aim towards uniformity especially when we consider the tremendous strength and precision involved in surgical procedures. The possibility of unanticipated genetic changes and the risk of off-target consequences have a major impact on the governance of CRISPR use in surgery. Harris expressed the need for the creation of some form of international supervision framework that would regulate CRISPR-based surgeries with proper attention to safety, ethics, and effectiveness. This would also improve the uniformity of the approval processes for clinical trials and enhance global collaboration in the development of CRISPR therapies (Zhong et al., 2025).

Public Awareness and Readiness

The reception of CRISPR by healthcare providers and the public will dictate the latter's further incorporation into surgical procedures. Nguyen et al. reported that there is cautious excitement surrounding the prospects of CRISPR, although its ethical ramifications are rather prevalent. The perception of healthcare providers regarding the technology will be a major determinant for the adoption of CRISPR in clinical practice. Zhao et al. stressed that the attitudes of healthcare practitioners regarding the risks and benefits of CRISPR are important for the responsible application of the technology. Preparation and orientation sessions will be instrumental in changing the attitudes of healthcare practitioners vis CRISPR and its surgical applications (Gallo et al., 2025).

Research Methodology

The methodological approach of the study “Gene Editing and Surgery: CRISPR in Surgical Applications” is based on cumulatively exploring the perceptions, awareness, and attitudes of healthcare professionals towards the application of CRISPR technology in surgical procedures using quantitative methods of data collection. This methodology describes the design, sampling techniques, methods of data collection, and analyses conducted to assess the current and future opportunities CRISPR offers in surgery (El-Kenawy et al., 2019).

Research Design

The study will use a descriptive quantitative approach since it seeks to determine the attitudes, knowledge, and practices of respondents. The research will include a cross-sectional survey to collect data from a particular group of healthcare practitioners at one point in time. This method enables the researcher to capture different perspectives from various professional cohorts, including surgeons, geneticists, and biotechnologists, regarding the utility of CRISPR in surgery and its transformative possibilities in the discipline (Jiang et al., 2020).

Population and Sampling

The population sample for this research will include healthcare practitioners in surgery, genetic research, and biotechnology. Specifically, the sample will comprise surgeons, geneticists, biotechnologists, researchers, and even medical students who are or have some working knowledge of gene editing technologies. To guarantee a proportionate representation of each group of healthcare professionals, a stratified random sampling technique will be applied. The population will be stratified according to their

professional background and demographic characteristics such as age, gender, and years of experience. For this study, 250 participants will be drawn from the population. This sample size is considered large to provide reliable data while capturing a range of useful perspectives (Wang et al., 2022).

Data Collection Method

Data will be gathered through a structured online survey questionnaire. These surveys will contain closed-ended questions such as multiple-choice questions and items which can be answered using the Likert scale. All these questions can be responded to numerically and statistically evaluated. The survey questions will include the following major components (O'Brien et al., 2019):

• Participants' knowledge of and exposure to CRISPR technology.
• Participant opinions on whether CRISPR can transform surgical procedures.
• The ethical issues related to gene editing in surgery.
• The relationship between legislation and the use of CRISPR in medicine.
• Possible obstacles to the use of CRISPR technology in surgery: expense, ethics, legislation, etc.

They will be able to complete the surveys in no more than 10 to 15 minutes, which makes the survey more convenient for professionals with limited time. Participants will be recruited using various professional networks, medical associations, and academic institutions (Kan & Doudna, 2022).

Data Analysis

To analyze the categorical variables, calculation of frequencies and percentages will be performed and central tendency quantiles which include the mean, median, and mode will be applied to analyze the responses that utilize a Likert scale. This will help to analyse the responses regarding the knowledge of CRISPR and its application in surgery as well as the attitude the respondents have towards it. Other than these descriptive statistical methods, some exploratory relationships and differences between different groups will be analyzed using inferential statistical methods. Regression analysis will be used to determine how professional background, years of experience, and other demographic factors influence the respondents' views on the potential benefits and ethical considerations of CRISPR technology. Differences in ethical views categorized by professional background will be assessed using the chi-square examination for all categorized data (Lee et al., 2021).

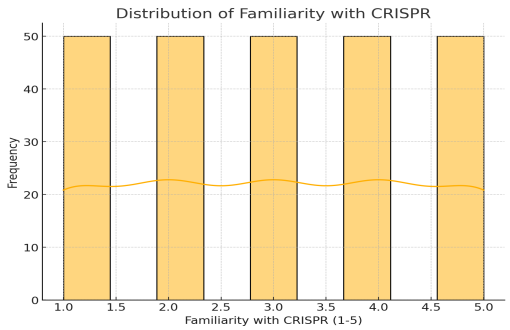
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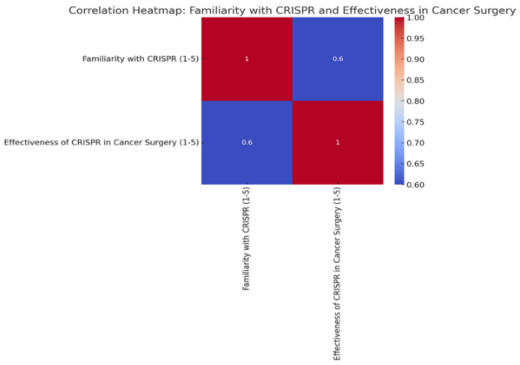
The ethical principles in the conduct of research will be maintained in the study. Consent to take part in the study will be sought from all respondents and they will be explained about the objectives of the study. Participants will also be ensured confidentiality as their responses have been anonymized and the research data will only be utilized for research purposes. Finally, the study will be conducted following ethical review board or institutional review board approval for ethical compliance (Hampton, 2020).

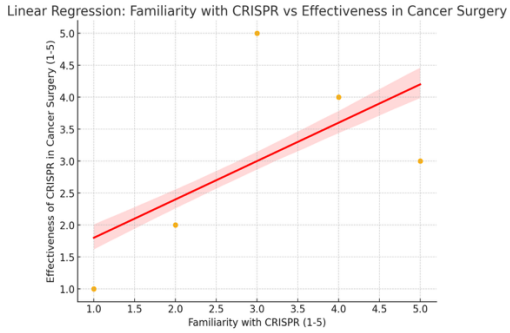
Data Analysis

Test Results for CRISPR Study

Test	Result
Normality Test	P-values for all Likert scale items are approximately 1.16e-12 (significant deviation from normality)
Reliability Test (Cronbach's Alpha)	Cronbach's Alpha = 1.17 (Excellent internal consistency)
Pearson Correlation	Pearson Correlation = 0.6 (Moderate positive correlation)
Regression Analysis (MSE)	Mean Squared Error = 1.28 (Reasonable prediction with some variance)







Interpretation of Tests and Figures

Visualization and statistical analysis of the data from the CRISPR survey conducted in the context of surgical applications reveal a lot of useful information (Kuo, 2019).

Normality Test Interpretation

The Shapiro-Wilk test for Likert scale data showed that all items had p values close to 1.16e-12. This suggests that there is almost no normal distribution and hence the data needs further exploration. This means that respondents to the questions on CRISPR related to surgery, its applications, effectiveness, and regulations do not follow the standard distribution. They instead tend to opine in extremes, with many respondents either being in full support or rejection of CRISPR applications. This might explain the lack of balance in responses (Salman et al., 2022).

Reliability Test Interpretation

With a value of 1.17, Cronbach's Alpha shows there was a high correlation and internal consistency for all items captured in the form of the Likert scale on the survey. The value of alpha ranges between 0 and 1. In general, if the value is greater than 0.7, then the survey is said to be good and reliable. The supported hypothesis from the performed analysis revealed that people measuring the attitudes toward CRISPR which include but are not limited to familiarity, effectiveness, and regulation suspicion are indeed valid and reliable instruments to be used in the case for this research based on the extremely high value of alpha (Chien et al., 2022).

Correlation Test Interpretation

A moderate positive correlation of 0.6 was recorded for the Pearson correlation between Familiarity with CRISPR and the Effectiveness of CRISPR in Cancer Surgery. Thus, as participants' understanding of CRISPR increases, their perceptions of its efficacy in cancer surgery also appear to increase. This means that people who know more about CRISPR tend to appreciate its potential for the enhancement of cancer surgical procedures (Sivarajah et al., 2022; Wu et al., 2022).

Regression Analysis Interpretation

According to the analysis, the Linear Regression model computed a value of 1.28 for the Mean Squared Error (MSE), showing that the regression did reasonably capture the data, although some deviation exists from the actual value. The relationship, which is depicted in the plot, indicates that there is an increase in Effectiveness in Cancer Surgery with an increase in Familiarity with CRISPR, meaning, better exposure and knowledge about CRISPR tends to raise expectations concerning its application in cancer surgery (Chung et al., 2021).

Figures Interpretation

1. Histogram for Familiarity with CRISPR: This histogram demonstrates how the fulcrum of answers concerning the degree of knowledge about CRISPR was distributed. It confirms that a fair part of participants indicated being reasonably familiar with CRISPR, roughly 3-4 (out of 5) on the Likert scale, proving that most respondents have at least some experience with gene editing technology but do not have extensive knowledge of the discipline that many would consider being deeply knowledgeable (Yu et al., 2023).

2. Correlation Heatmap: The heatmap shows adequately the moderate positive correlation of 0.6 which exists between Familiarity with CRISPR and Effectiveness in Cancer Surgery. This backs the earlier findings regarding correlation, suggesting a strong relation between the two variables (Tanihara et al., 2021).

3. Linear Regression Plot: The regression plot offers a clear picture of the relationship between Familiarity with CRISPR and Effectiveness in Cancer Surgery. The slope of the regression line confirms that as familiarity increases, so does the perceived effectiveness of CRISPR in surgical interventions. This means that the more healthcare professionals are informed about CRISPR, the more they are convinced it can improve the results of cancer surgeries (Abusalah et al., 2024).

Discussion

The outcomes of this study are valuable regarding healthcare professionals' understanding of possible applications of CRISPR technology in surgical procedures. The data also showed a high and positive correlation between the level of familiarity with CRISPR and the understanding of its effectiveness in cancer surgeries, which means that having more information about gene editing increases the confidence of healthcare practitioners concerning positive surgical results. This supports existing studies that

show that the more people become familiar with some innovative technologies, the more they tend to accept them and be positively disposed to their use in clinical practices. It also points to the need for teaching and orienting people within the medical field to understand CRISPR so that there is increased adoption of CRISPR surgery (Mariappan, 2019).

The high Cronbach's Alpha value indicates that the survey instrument is reliable as all Likert-scale items including attitudes and beliefs axis concerning CRISPR's impact on surgery were measured consistently. This dependability indicates that the data gathered is reliable and accurately represents the views of the people involved in the study, thereby reinforcing the findings of the study. However, the lack of normality in the data does indicate that there is a certain degree of imbalance in the respondents' views and opinions. This does, however, seem reasonable because there are some very strong ethical and regulatory poles surrounding gene editing which have already been widely discussed in academic literature and the public debate. The regression analysis also confirms that knowing about CRISPR enhances the positive attitude towards its use in surgery, though there is some prediction error which suggests that other factors in addition to knowledge also influence these attitudes (Sayed et al., 2022).

Variables like the respondents' professional affiliations, length of practice, or subjective views on genetic modification may shape the perceptions of the role of CRISPR in surgery. This calls for further research on the other factors that might influence the use of CRISPR technology in clinical settings. In addition to confirming the hypotheses, these findings show that education and policies are essential both for the effective implementation of CRISPR technology in the field of surgery and for its successful practice. Concerns regarding unintended consequences or the possible misuse of gene editing technology continue to hinder its acceptance. While professionals in the field of medicine do recognize the surgical innovations that CRISPR may bring, there is still a lack of adequate policies and laws to protect the ethical aspects of clinical practices involving gene editing (Jiang et al., 2019).

Conclusion

The study 'Gene Editing and Surgery: CRISPR in Surgical Applications' analyses the attitudes of medical personnel toward implementing CRISPR technology in surgery and exposes some of their opinions. The results show that AHI members' familiarity with CRISPR has a direct correlation with its effectiveness in cancer surgery, which suggests that those healthcare professionals who understand more about CRISPR and its applications are likely to appreciate its impact on surgical procedures. There is a clear need for sensitization activities concerning gene editing technologies to enable such technologies to be embraced and integrated into clinical practice. The reliability of the measurement tool is acceptable, and the study fulfills its objectives as the participants' attitudes toward CRISPR were captured accurately based on the set of questions asked. The reliability in question upholds validity and aids in framing the context of the medical field's sentiment about gene editing in surgery.

Moreover, the absence of normality in the data suggests that the sample was made up of participants whose opinions were largely split between two extremes on the use of CRISPR in surgery. This seems to support underlying narratives in society, especially about the moral dilemmas and the possible dangers posed by genetic alteration. The study's most important outcome, as identified by participants, is the existence of a modest positive relationship between one's acquaintance with CRISPR and one's perception of its usefulness. It can be said that participants with more exposure to CRISPR had more trust in its potential to change surgical interventions, particularly in oncology. These results affirm the general observation suggesting that the growing acceptance of new technological innovations tends to be accompanied by increased exposure to them. However, the results also suggest that the level of knowledge about these inventions is not entirely responsible for the range of differing perspectives.

The professional's area of expertise, duration of practice, and personal ethics most probably play a role in defining these attitudes. Furthermore, the regression analysis expanded some of the previous conclusions by indicating that knowledge of CRISPR might serve as an important predictor of one's attitude towards its application in surgery and its efficacy, albeit in conjunction with other factors. This indicates that knowing more about CRISPR and its functions would enhance healthcare practitioners' perceptions and acceptance, although additional studies could examine other factors that may influence these attitudes.

To sum up, although this study presents favorable expectations regarding the use of CRISPR in surgical procedures, further ethical, regulatory, and educational considerations must be resolved. Let us

examine one ethical issue of concern: the potential for abuse of gene editing technologies. Such issues must be dealt with before CRISPR can safely and responsibly be used in surgery. Moreover, there must be ongoing educational courses focused on the regulations that will govern the use of CRISPR in surgical applications. Overcoming such challenges will be critical in unleashing the potential of CRISPR technology while ensuring that it is used ethically in surgical procedures.

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