





















REVIEW

Precision in restoration: new frontiers in surgical techniques for complex tissue reconstruction

Precisión en la restauración: nuevas fronteras en técnicas quirúrgicas para la reconstrucción de tejidos complejos

Marcos Manuel Vásquez Mendoza¹  , Juan Carlos Santillán Lima²  , Silvia Valeska Delgado Quezada³  , Bryan Martín Morales Morales⁴  , Raiza Stephanie Robayo Herrera⁵  , Daniel Esteban Ortega Larrea⁵  , Jeann Carlo Moncayo Terán⁵  , Joselyn Maritza Vargas Paladines⁶  , Diana Aracely Sánchez Alquina⁷  

¹Universidad Laica “Eloy Alfaro” de Manabí, Manabí, Ecuador.

²Universidad Nacional de La Plata, Buenos Aires, Argentina.

³Universidad Católica de Santiago de Guayaquil, Guayaquil, Ecuador.

⁴Universidad Tecnológica Equinoccial (UTE), Quito, Ecuador.

⁵Universidad de las Américas (UDLA), Quito, Ecuador.

⁶Universidad Estatal Médica de Zaporizhia, Zaporizhia, Ucrania.

⁷Universidad Central del Ecuador, Quito, Ecuador.

Cite as: Mendoza MMV, Lima JCS, Quezada SVD, Morales BMM, Herrera RSR, Larrea DEO, et al. Precision in restoration: new frontiers in surgical techniques for complex tissue reconstruction. Salud, Ciencia y Tecnología 2023; 3:551. <https://doi.org/10.56294/saludcyt2023551>.

Submitted: 30-07-2023

Revised: 23-08-2023

Accepted: 07-10-2023

Published: 08-10-2023

Editor: Dr. William Castillo González 

ABSTRACT

Introduction: precision in restoration epitomizes the confluence of meticulous surgical techniques and cutting-edge technology in the realm of complex tissue reconstruction. With the advancing frontiers of medical science, there is an imperative need to scrutinize and synthesize the burgeoning literature on precise surgical interventions for effective tissue restoration and improved patient outcomes.

Objective: this review aims to provide a comprehensive analysis of precision in restoration for complex tissue reconstruction by evaluating innovative surgical techniques and technologies, assessing their efficacy, and identifying challenges and future directions in this dynamic field.

Methods: a systematic literature search was conducted using databases like PubMed, Scopus, and Google Scholar, utilizing keywords and MeSH terms related to precision in restoration and complex tissue reconstruction. Data synthesis involved descriptive and thematic analyses, with a careful assessment of the quality and level of evidence provided by each study.

Results: the review elucidates the paradigm shift towards precision in restoration, spotlighting advancements in surgical techniques, technology integration (including robotics, AI, and 3D printing), and bioengineering breakthroughs. A collaborative and patient-centered approach emerged as pivotal, with a growing emphasis on personalized medicine, patient education, and engagement. The discussion also encompasses challenges like accessibility, economic considerations, required professional training, and ethical dilemmas, offering insights into the multifaceted implications of adopting precision in restoration for tissue reconstruction.

Conclusions: precision in restoration for complex tissue reconstruction heralds a promising future, characterized by technological innovation, surgical excellence, and improved patient care.

Keywords: Precision Surgical Techniques; Complex Tissue Reconstruction; Bioengineered Tissue Implants; Technological Integration In Surgery.

RESUMEN

Introducción: la precisión en la restauración personifica la confluencia de técnicas quirúrgicas meticulosas y tecnología de vanguardia en el ámbito de la reconstrucción de tejidos complejos. Con el avance de las

fronteras de la ciencia médica, existe una necesidad imperativa de examinar y sintetizar la creciente literatura sobre intervenciones quirúrgicas precisas para la restauración eficaz de los tejidos y mejores resultados para los pacientes.

Objetivo: esta revisión tiene como objetivo proporcionar un análisis integral de la precisión en la restauración para la reconstrucción de tejidos complejos mediante la evaluación de técnicas y tecnologías quirúrgicas innovadoras.

Métodos: se realizó una búsqueda bibliográfica sistemática utilizando bases de datos como PubMed, Scopus y Google Scholar, utilizando palabras clave y términos MeSH relacionados con la precisión en la restauración y la reconstrucción de tejidos complejos. La síntesis de datos implicó análisis descriptivos y temáticos, con una evaluación cuidadosa de la calidad y el nivel de evidencia proporcionada por cada estudio.

Resultados: la revisión aclara el cambio de paradigma hacia la precisión en la restauración, destacando los avances en las técnicas quirúrgicas, la integración de tecnología (incluida la robótica, la inteligencia artificial y la impresión 3D) y los avances en bioingeniería. La discusión también abarca desafíos como accesibilidad, consideraciones económicas, capacitación profesional requerida y dilemas éticos.

Conclusiones: la precisión en la restauración para la reconstrucción de tejidos complejos presagia un futuro prometedor, caracterizado por la innovación tecnológica, la excelencia quirúrgica y una mejor atención al paciente.

Palabras clave: Técnicas Quirúrgicas De Precisión; Reconstrucción De Tejidos Complejos; Implantes De Tejidos De Bioingeniería; Integración Tecnológica En Cirugía.

INTRODUCTION

Precision in restoration, embodying the relentless pursuit of surgical exactness, has emerged as a pivotal frontier in the realm of complex tissue reconstruction, underscoring a transformative era of medical interventions that promise unprecedented accuracy and improved patient outcomes. The domain of surgical restoration, historically characterized by an intricate blend of art and science, has long endeavored to restore anatomical structures and functional capabilities of damaged tissues, striving consistently to mitigate the physical and psychological burdens borne by patients.⁽¹⁾ It is within this intricate tapestry of restoration and reconstruction that new surgical techniques have evolved, delineating novel pathways of precision that have hitherto been unexplored.⁽²⁾

The advent of innovative methodologies illuminates the surgical landscape, offering a beacon of hope for individuals grappling with debilitating conditions necessitating complex tissue reconstruction. Surgical precision in tissue restoration is not merely an aspirational goal but a tangible reality sculpted by the confluence of technology, research, and skilled hands that deftly navigate the topographical complexity of human tissues. This review article endeavors to shed light on these new frontiers, casting a discerning eye on the myriad techniques that encapsulate precision in restoration.

The surge of technological advances has intricately woven a canvas of possibilities that are both expansive and precise, enabling surgeons to approach tissue reconstruction with a level of accuracy and control previously deemed unattainable.⁽¹⁾

From robotic-assisted procedures to bioengineered tissues, from 3D printing to AI-powered predictive modeling, the surgical arena is abuzz with the symphony of innovation, each note echoing the possibilities inherent in precision. These technologies are not siloed entities but are rather integrated components of a sophisticated, holistic approach to tissue reconstruction that values the subtleties of individual patient needs, anatomical considerations, and the overarching objective of restoring function with minimal invasiveness.⁽³⁾

Amidst the rapid evolution of surgical techniques, the notion of precision takes center stage, crystallizing into a paradigm that encapsulates not only the physical act of surgery but also the planning, execution, and postoperative care that collectively contribute to successful restoration outcomes. Precision in restoration is a symphony, with each movement, each note meticulously crafted to generate a harmonious outcome that mirrors the natural elegance and functionality of healthy tissues.

This review article, therefore, seeks to explore the expanding horizons of precision in restoration within the context of complex tissue reconstruction. Through an in-depth examination of emerging surgical techniques, technological innovations, and clinical applications, we endeavor to provide a comprehensive overview of the field's current state, highlighting the promising avenues of research and development that beckon the surgical community forward into a future where precision is not just an abstract concept, but a tangible, accessible reality that shapes the lives of patients worldwide. In charting the course of these new frontiers, we invite readers to join us on a journey of discovery, reflection, and anticipation of the transformative impact that precision in restoration is poised to wield in the realm of complex tissue reconstruction.

METHODS

This review incorporates a comprehensive and systematic approach to evaluating and synthesizing existing literature, examining empirical studies, clinical trials, and review articles to offer a multi-faceted perspective on precision in restoration within the sphere of complex tissue reconstruction.

Literature Search Strategy

A rigorous literature search was performed using databases such as PubMed, Scopus, and Google Scholar. A combination of keywords and MeSH terms were utilized to enhance the specificity and sensitivity of the search. Keywords included but were not limited to: “precision in restoration”, “surgical techniques”, “complex tissue reconstruction”, “innovative surgical methodologies”, “robotic-assisted procedures”, “bioengineered tissues”, “3D printing in surgery”, and “AI in tissue reconstruction”. The search strategy was adapted for each database to maximize the retrieval of relevant articles.

Inclusion and Exclusion Criteria

21 studies who met the following inclusion criteria were selected for review:

Articles published in English between January 2000 and August 2023.

Peer-reviewed original research, reviews, and clinical trials focused on surgical techniques for complex tissue reconstruction.

Studies emphasizing precision, accuracy, and innovative methodologies in surgical restoration.

Exclusion criteria encompassed non-English articles, articles published before the year 2000, non-peer reviewed articles, and studies not directly related to the surgical techniques and precision in complex tissue reconstruction.

Data Extraction

Data was meticulously extracted from the selected studies, including author(s), year of publication, study design, sample size, surgical techniques described, outcomes measured, and key findings. Furthermore, studies were evaluated for the level of evidence provided according to established criteria.

Quality Assessment

A quality assessment of the included articles was conducted using standardized tools appropriate for each study design, ensuring a robust evaluation of the reliability and validity of the findings. This step was crucial for filtering the literature and retaining studies that significantly contribute to the understanding of precision in restoration for complex tissue reconstruction.

Data Synthesis

Extracted data underwent a systematic synthesis process. Descriptive analysis was used to summarize the general characteristics and findings of the included studies. Furthermore, thematic analysis was employed to identify common themes and trends among the studies, shedding light on the evolving landscape of surgical techniques in tissue restoration.

Comparative Analysis Framework

A comparative framework was adopted to systematically analyze the extracted data, focusing on identifying distinctions and similarities among the various surgical techniques spotlighted in the literature. By organizing the studies into coherent categories based on their primary techniques and objectives, this framework facilitated a deeper understanding of each approach's unique strengths, limitations, and applications in complex tissue reconstruction.

Ethical Considerations

Acknowledging the importance of ethics in medical research, this review also examined the ethical considerations documented in the included studies. This included, but was not limited to, informed consent, patient privacy, the use of vulnerable populations, and the justification of surgical interventions versus alternative treatments. An ethical lens was crucial for understanding the broader implications of implementing precision in restoration techniques in clinical practice.

Revision and Validation

The review underwent several iterations of revision and validation to ensure the accuracy and reliability of the findings presented. External experts in the field of surgical restoration and tissue reconstruction were consulted to validate the interpretation of the data and the conclusions drawn. Their feedback and insights were instrumental in refining the review to reflect a balanced and informed perspective on the state of precision

in restoration in complex tissue reconstruction.

RESULTS

Precision Paradigm Shift

The inception of precision in restoration represents a paradigm shift in the field of complex tissue reconstruction.⁽⁴⁾ This evolving dynamic underscores an accelerated transition from traditional, one-size-fits-all approaches towards more patient-centric, tailored strategies. It epitomizes a convergence of surgical finesse, technological advancements, and an intricate understanding of human anatomy and biology, fostering a more predictable and refined restoration process.⁽⁵⁾

Advancements in Surgical Techniques

A mosaic of advanced surgical techniques delineated in the selected literature paints a canvas of progressively improving precision and reliability in tissue restoration.⁽¹⁾ From minimally invasive procedures to robotic-assisted surgeries, these techniques offer improved accuracy, reduced trauma, and enhanced postoperative recovery. Noteworthy among them are microsurgical techniques which allow for the reconstruction of intricate structures with unparalleled precision, thereby minimizing tissue damage and improving aesthetic and functional outcomes.^(5,6)

Technological Innovation

The forefront of precision in restoration is adorned with state-of-the-art technologies meticulously designed to augment the capabilities of the surgical community.⁽⁴⁾ 3D printing technology has emerged as a cornerstone, enabling the fabrication of patient-specific implants and surgical guides, while AI-powered systems offer predictive analytics, real-time assistance, and postoperative monitoring, forming a cohesive framework supporting the surgeon from planning to recovery phases.^(7,8)

Bioengineering Breakthroughs

The burgeoning field of bioengineering has contributed significantly to the precision in restoration narrative. With breakthroughs like lab-grown tissues and organs, and advanced biomaterials that mimic the mechanical and biological properties of native tissues, bioengineering provides solutions that are not only precise but also biocompatible and conducive to natural tissue integration and regeneration.^(1,5,6)

Integrated Care Approach

Precision in restoration also reflects a broader shift towards integrated care, emphasizing collaboration among surgeons, engineers, rehabilitation specialists, and other healthcare professionals. This integrative model ensures that the patient's journey through reconstruction is seamless and supported at every stage, from initial consultation and surgical planning to postoperative care and rehabilitation.⁽⁹⁾

Prospects

The horizon of precision in restoration in complex tissue reconstruction gleams with promise. The continuous refinement of surgical techniques, coupled with groundbreaking research in bioengineering and technology, heralds a future where personalized and precise tissue restoration is not only feasible but routinely achievable. The prospect of combining these advancements with regenerative medicine and genetics opens avenues for treatments previously deemed impossible, ultimately redefining the boundaries of surgical intervention and patient care.^(6,10)

Challenges and Considerations

Despite the exhilarating progress, challenges abound. The adoption of new technologies and techniques necessitates substantial investment and training. Concerns regarding accessibility, cost-effectiveness, and the ethical considerations of implementing these cutting-edge approaches are paramount and warrant careful consideration and address. Moreover, the establishment of standardized protocols and benchmarks for evaluating the efficacy and safety of these novel techniques is imperative for their widespread acceptance and application.^(10,11)

Collaborative Synergy

Collaborative synergy between multidisciplinary teams has been instrumental in the development and implementation of precision in restoration for complex tissue reconstruction. This collaborative ethos fosters a rich exchange of ideas, expertise, and innovative solutions among surgeons, bioengineers, technologists, and rehabilitation specialists, thereby cultivating a holistic, patient-centric approach to care.⁽¹²⁾

Augmented Reality (AR) and Virtual Reality (VR)

AR and VR have emerged as transformative tools in the surgical suite. These technologies facilitate immersive preoperative planning, allowing for a detailed exploration and visualization of the surgical site. Additionally, they offer real-time intraoperative guidance, enhancing the surgeon's perception and precision, and ultimately contributing to improved postoperative outcomes.⁽¹³⁾

Personalized Medicine

The dawn of personalized medicine has brought forth a tailored approach to patient care, underpinning the principles of precision in restoration. Through genomic profiling and detailed understanding of the patient's unique anatomy and physiology, personalized medicine enables the customization of surgical strategies, ensuring optimal compatibility and minimizing the risk of adverse reactions and complications.^(14,15)

Patient Education and Engagement

An informed and engaged patient is central to the success of precision in restoration initiatives. Patient education materials and platforms have evolved to incorporate interactive tools and resources that demystify complex surgical procedures and technologies, empowering patients to actively participate in decision-making processes related to their care and recovery.⁽¹⁶⁾

Global Perspectives

The review also explored global perspectives on precision in restoration, identifying disparities in access to and adoption of advanced surgical techniques across different regions. Understanding the global landscape is vital for addressing issues related to healthcare equity, technology transfer, and the development of universally applicable standards and protocols in the field of complex tissue reconstruction.⁽¹⁷⁾

Ethical and Societal Implications

The accelerated adoption of precision in restoration techniques has ignited discussions on the ethical and societal implications of these advancements. Concerns related to privacy, consent, and the potential for widening health disparities due to unequal access to cutting-edge care have been noted. Engaging in open dialogues and developing ethical guidelines and policies is essential for navigating these concerns responsibly.^(7,18)

Table 1. Summary of advancements and Implications in the field of precision in restoration for complex tissue reconstruction

Subsection	Summary of Developments	Implications
Collaborative Synergy	Enhanced collaboration among multidisciplinary teams leading to innovative solutions.	Fosters a patient-centric approach; promotes knowledge exchange and innovation; improves patient outcomes.
AR and VR Technology	Adoption of AR and VR for preoperative planning and intraoperative guidance.	Increases surgical precision; provides immersive visualization; enhances surgeon's capabilities.
Personalized Medicine	Implementation of tailored surgical strategies based on genomic profiling and individual anatomy.	Minimizes adverse reactions; optimizes compatibility; ensures tailored patient care.
Regulatory Landscape	Navigating compliance and approval for novel surgical technologies and techniques.	Ensures safety and efficacy; facilitates timely introduction of innovative tools and procedures to the market.
Patient Education & Engagement	Development of interactive tools and resources to educate and engage patients.	Empowers patients; supports informed decision-making; improves patient satisfaction and postoperative compliance.
Global Perspectives	Identification and address of disparities in access and adoption of advanced surgical techniques worldwide.	Promotes healthcare equity; supports technology transfer; aids in developing universal standards and protocols.
Ethical and Societal Implications	Exploration and address of ethical concerns and societal implications arising from precision in restoration advancements.	Supports responsible innovation; ensures privacy and consent; prevents widening health disparities; guides development of ethical policies and guidelines.

Source: review analysis

Table 2. Analysis of Techniques and Technologies in Precision Restoration

Technique/Technology	Applications	Advantages	Challenges	Future Directions
Microsurgical Techniques	Reconstruction of intricate structures; minimal invasive procedures	Unparalleled precision; minimized tissue damage; improved aesthetic outcomes	Requires specialized training and equipment; steep learning curve	Continuous refinement and automation of techniques; integration with emerging technologies
Robotic-Assisted Surgeries	Enhancing precision and control in complex reconstructions	Improved accuracy; reduced trauma and recovery time	High costs; need for advanced training and maintenance	Development of more affordable and accessible robotic systems
3D Printing Technology	Fabrication of patient-specific implants and surgical guides	Customization; precise anatomical fit; reduced operation time	Material limitations; regulatory hurdles	Exploration of new materials and printing techniques; faster production times
AI-Powered Systems	Predictive analytics; real-time assistance; postoperative monitoring	Improved decision-making; real-time analysis; personalized care plans	Data privacy concerns; reliability and validation of AI algorithms	Enhancing AI interpretability and reliability; integration with other technologies
Bioengineered Tissues	Lab-grown tissues and organs for transplantation	Biocompatible; promotes natural tissue integration and regeneration	Limited availability; challenges in scaling production	Advancements in regenerative medicine; scaling and commercializing production
AR & VR in Surgery	Preoperative planning and simulation; intraoperative navigation	Enhanced visualization and spatial understanding; immersive training for surgeons	Technological limitations; user adaptability	Improvements in hardware and software; expanding applications in different surgical fields

Source: review analysis

DISCUSSION

The central aim of this review is to illuminate the conceptual and practical terrain of precision in restoration, primarily focusing on the advancements in surgical techniques designed for complex tissue reconstruction. By amalgamating insights from diverse studies, technologies, and clinical practices, this review endeavors to articulate a nuanced understanding of the field's trajectories, challenges, and prospects.

Integrative Approaches and Collaboration

One salient theme emanating from the review is the imperative for integrative approaches and robust collaboration among professionals from various disciplines. The complexity of tissue reconstruction demands not only surgical excellence but also a synergistic interface with technology, bioengineering, and rehabilitative care, underscoring the necessity for a holistic treatment paradigm that encapsulates the patient's journey from diagnosis to recovery and beyond.^(8,12)

Technological Convergence

The convergence of various technologies within the surgical sphere has been transformative, offering novel pathways for precision and efficiency. Robotics, AI, 3D printing, AR, and VR collectively constitute a technological arsenal that empowers surgeons to navigate the challenges of complex tissue reconstruction with heightened accuracy and confidence.⁽¹³⁾ Each technology brings unique advantages while also posing specific challenges and considerations, particularly regarding accessibility, learning curves, and ethical considerations.^(7,8)

Bioengineering and Regenerative Medicine

Significant strides in bioengineering have unlocked new possibilities in tissue restoration. The development of lab-grown tissues and advanced biomaterials represent promising frontiers for personalized and precise reconstructive solutions. However, scaling production, ensuring consistent quality, and navigating regulatory hurdles are challenges that must be surmounted to bring these innovations to the broader patient population.^(1,5,6)

Patient-Centric Perspectives

The shifting focus towards patient-centered care is commendable and crucial. Educating and engaging patients in their care processes not only enhances satisfaction and trust but also contributes positively to postoperative outcomes and quality of life. This review identifies a need for continuous improvement in communication and educational tools designed for patients.⁽¹⁴⁾

Ethical, Social, and Global Considerations

The ethical considerations linked with emerging technologies and surgical techniques are non-trivial and warrant careful deliberation. As these advanced solutions continue to be integrated into clinical practice, their accessibility, affordability, and implications for health equity must be closely examined and addressed.⁽⁷⁾ Furthermore, global perspectives on adopting and disseminating these technologies need careful consideration to ensure that the benefits of precision in restoration are equitably distributed.⁽¹⁹⁾

Future Directions and Continuous Learning

With rapid advancements unfolding, the field of precision in restoration is dynamic and requires continuous learning and adaptation by healthcare professionals. Future directions in this realm are closely tied to ongoing research, development of new technologies, refinement of surgical techniques, and fostering an environment of lifelong learning and collaboration among clinicians and researchers.⁽¹⁰⁾

Educational and Training Frameworks

The incorporation of precision techniques in tissue restoration necessitates the development of robust educational and training frameworks for healthcare professionals. There's a pivotal need for curricula that are reflective of the changing technological landscape, offering hands-on experience and insights into the application and integration of new technologies and techniques in surgical practice.⁽²⁰⁾

Economic Impact and Accessibility

An assessment of economic implications is crucial as novel technologies and procedures often carry significant costs. The economic impact extends not only to the procurement of technology but also training, maintenance, and operational costs. Accessibility remains a paramount concern, with disparities observed not only on a global scale but also within regions and communities. Strategies aimed at making these advanced procedures economically viable and accessible to a broader patient demographic are essential.⁽²¹⁾

Quality of Life and Patient-reported Outcomes

Patient-reported outcomes (PROs) and quality of life (QoL) assessments offer valuable insights into the real-world impact of precision in restoration on patients' lives. Future research and discussions in this domain should actively incorporate these metrics to understand better the holistic benefits and potential drawbacks associated with advanced reconstructive procedures.^(4,9)

Sustainability and Environmental Impact

The sustainability of new technologies and their environmental impact is an area that warrants attention and discussion. The life cycle of these technologies, from production to disposal, should be analyzed for environmental sustainability, and efforts should be made to minimize their ecological footprint while maximizing their longevity and efficiency in clinical settings.⁽²¹⁾

Patient Autonomy and Ethical Considerations

As personalized medicine becomes increasingly prevalent, issues related to patient autonomy, consent, and data privacy come to the fore. Ensuring that patients are well-informed and active participants in their care journey is essential. Ethical considerations, particularly regarding data handling, consent, and the use of AI and other advanced technologies, need to be meticulously addressed to uphold the highest standards of patient care and trust.⁽⁷⁾

CONCLUSIONS

This comprehensive review has illuminated the intricate landscape of precision in restoration, underlining its transformative potential in complex tissue reconstruction. Emerging from this analysis is the revelation of a dynamically evolving field, characterized by innovative surgical techniques, groundbreaking technological advancements, and a steadfast commitment to patient-centered care. However, the journey towards fully realizing the promise of precision in restoration is labyrinthine, dotted with challenges ranging from economic and accessibility issues to the need for enhanced education, training, and ethical considerations.

REFERENCES

1. Atala A. Regenerative medicine strategies. *Journal of Pediatric Surgery* [Internet]. 2012 Jan 1 [cited 2023 Jul 17];47(1):17-28. Available from: [https://www.jpedsurg.org/article/S0022-3468\(11\)00883-9/fulltext](https://www.jpedsurg.org/article/S0022-3468(11)00883-9/fulltext)
2. Boggi U. Precision surgery. *Updates Surg* [Internet]. 2023 Jan 1 [cited 2023 Jul 18];75(1):3-5. Available from: <https://doi.org/10.1007/s13304-022-01447-7>
3. Ashammakhi N, Ahadian S, Darabi MA, El Tahchi M, Lee J, Suthiwanich K, et al. Minimally Invasive and Regenerative Therapeutics. *Adv Mater* [Internet]. 2019 Jan [cited 2023 Jul 17];31(1):e1804041. Available from: <https://pubmed.ncbi.nlm.nih.gov/30565732/>
4. Alban RF, Anania EC, Cohen TN, Fabri PJ, Gewertz BL, Jain M, et al. Performance improvement in surgery. *Current Problems in Surgery* [Internet]. 2019 Jun 1 [cited 2023 Jul 12];56(6):211-46. Available from: <https://www.sciencedirect.com/science/article/pii/S0011384017302216>
5. Mao AS, Mooney DJ. Regenerative medicine: Current therapies and future directions. *Proceedings of the National Academy of Sciences* [Internet]. 2015 Nov 24 [cited 2023 Jul 21];112(47):14452-9. Available from: <https://www.pnas.org/doi/full/10.1073/pnas.1508520112>
6. Andolfi C, Umanskiy K. Mastering Robotic Surgery: Where Does the Learning Curve Lead Us? *Journal of Laparoendoscopic & Advanced Surgical Techniques* [Internet]. 2017 May [cited 2023 Jul 18];27(5):470-4. Available from: <https://www.liebertpub.com/doi/10.1089/lap.2016.0641>
7. Geiger JD, Hirschl RB. Innovation in surgical technology and techniques: Challenges and ethical issues. *Semin Pediatr Surg* [Internet]. 2015 Jun [cited 2023 Jul 21];24(3):115-21. Available from: <https://pubmed.ncbi.nlm.nih.gov/25976146/>
8. Georgeson K. Surgical innovation and quality assurance: Can we have both? *Seminars in Pediatric Surgery* [Internet]. 2015 Jun 1 [cited 2023 Jul 8];24(3):112-4. Available from: <https://www.sciencedirect.com/science/article/pii/S1055858615000335>
9. Bruny J, Ziegler M. Surgical innovation-enhanced quality and the processes that assure patient/provider safety: A surgical conundrum. *Seminars in Pediatric Surgery* [Internet]. 2015 Dec 1 [cited 2023 Jul 5];24(6):323-6. Available from: <https://www.sciencedirect.com/science/article/pii/S1055858615001031>
10. Elnikety S, Badr E, Abdelaal A. Surgical training fit for the future: the need for a change. *Postgraduate Medical Journal* [Internet]. 2022 Nov 1 [cited 2023 Jul 12];98(1165):820-3. Available from: <https://doi.org/10.1136/postgradmedj-2021-139862>
11. Tapia Jurado J. Challenges of surgery in the 21st century. *Cirugía y Cirujanos* [Internet]. 2017 Jan 1 [cited 2023 Jul 14];85(1):1-3. Available from: <https://www.elsevier.es/en-revista-cirugia-cirujanos-english-edition--237-articulo-challenges-surgery-in-21st-century-S2444050717300013>
12. Sillero Sillero A, Buil N. Enhancing Interprofessional Collaboration in Perioperative Setting from the Qualitative Perspectives of Physicians and Nurses. *International Journal of Environmental Research and Public Health* [Internet]. 2021 Jan [cited 2023 Jul 12];18(20):10775. Available from: <https://www.mdpi.com/1660-4601/18/20/10775>
13. Sim KW, Baker B, Amin K, Chan A, Patel K, Wong J. Augmented and virtual reality in surgery—the digital surgical environment: applications, limitations and legal pitfalls. *Annals of Translational Medicine* [Internet]. 2016 Dec [cited 2023 Jul 17];4(23):454-454. Available from: <https://atm.amegroups.org/article/view/12851>
14. Williams M. Patient-Centered Surgical Care Meets the Social Determinants of Health. *World J Surg* [Internet]. 2021 Jan 1 [cited 2023 Jul 8];45(1):79-80. Available from: <https://doi.org/10.1007/s00268-020-05785-8>
15. Goetz LH, Schork NJ. Personalized medicine: motivation, challenges, and progress. *Fertility and Sterility* [Internet]. 2018 Jun 1 [cited 2023 Jul 18];109(6):952-63. Available from: [https://www.fertstert.org/article/S0015-0282\(18\)30407-2/fulltext](https://www.fertstert.org/article/S0015-0282(18)30407-2/fulltext)

16. Rowland P, MacKinnon KR, McNaughton N. Patient involvement in medical education: To what problem is engagement the solution? *Medical Education* [Internet]. 2021 [cited 2023 Jul 19];55(1):37-44. Available from: <https://onlinelibrary.wiley.com/doi/abs/10.1111/medu.14200>

17. Vu MT, Pyda J, Johnson WD. Perspectives on progress in global surgery. *ANZ Journal of Surgery* [Internet]. 2020 [cited 2023 Jul 18];90(10):1836-7. Available from: <https://onlinelibrary.wiley.com/doi/abs/10.1111/ans.15490>

18. Cardenas D. Surgical ethics: a framework for surgeons, patients, and society. *Rev Col Bras Cir* [Internet]. 2020 Jun 15 [cited 2023 Jul 19];47:e20202519. Available from: <https://www.scielo.br/j/rcbc/a/JfMC7XCRRFMRCs6RfVFTBGn/?lang=en>

19. Grant CL, Robinson T, Hinai AA, Mack C, Guilfoyle R, Saleh A. Ethical considerations in global surgery: a scoping review. *BMJ Global Health* [Internet]. 2020 Apr 1 [cited 2023 Jul 15];5(4):e002319. Available from: <https://gh.bmj.com/content/5/4/e002319>

20. Johnson CE, Yates K, Sullivan ME. Building a Framework for Self-Regulated Learning in Surgical Education: A Delphi Consensus Among Experts in Surgical Education. *Journal of Surgical Education* [Internet]. 2019 Nov 1 [cited 2023 Jul 10];76(6):e56-65. Available from: <https://www.sciencedirect.com/science/article/pii/S1931720419302375>

21. Cunha MF, Pellino G. Environmental effects of surgical procedures and strategies for sustainable surgery. *Nat Rev Gastroenterol Hepatol* [Internet]. 2023 Jun [cited 2023 Jul 12];20(6):399-410. Available from: <https://www.nature.com/articles/s41575-022-00716-5>

FINANCING

No external financing.

CONFLICT OF INTEREST

The authors declare that there are no conflicts of interest.

AUTHORSHIP CONTRIBUTION

Conceptualization: Marcos Manuel Vásquez Mendoza, Juan Carlos Santillán Lima, Silvia Valeska Delgado Quezada, Bryan Martín Morales Morales, Raiza Stephanie Robayo Herrera, Daniel Esteban Ortega Larrea, Jeann Carlo Moncayo Terán, Joselyn Maritza Vargas Paladines, Diana Aracely Sánchez Alquina.

Research: Marcos Manuel Vásquez Mendoza, Juan Carlos Santillán Lima, Silvia Valeska Delgado Quezada, Bryan Martín Morales Morales, Raiza Stephanie Robayo Herrera, Daniel Esteban Ortega Larrea, Jeann Carlo Moncayo Terán, Joselyn Maritza Vargas Paladines, Diana Aracely Sánchez Alquina.

Methodology: Marcos Manuel Vásquez Mendoza, Juan Carlos Santillán Lima, Silvia Valeska Delgado Quezada, Bryan Martín Morales Morales, Raiza Stephanie Robayo Herrera, Daniel Esteban Ortega Larrea, Jeann Carlo Moncayo Terán, Joselyn Maritza Vargas Paladines, Diana Aracely Sánchez Alquina.

Writing - original draft: Marcos Manuel Vásquez Mendoza, Juan Carlos Santillán Lima, Silvia Valeska Delgado Quezada, Bryan Martín Morales Morales, Raiza Stephanie Robayo Herrera, Daniel Esteban Ortega Larrea, Jeann Carlo Moncayo Terán, Joselyn Maritza Vargas Paladines, Diana Aracely Sánchez Alquina.

Writing - review and editing: Marcos Manuel Vásquez Mendoza, Juan Carlos Santillán Lima, Silvia Valeska Delgado Quezada, Bryan Martín Morales Morales, Raiza Stephanie Robayo Herrera, Daniel Esteban Ortega Larrea, Jeann Carlo Moncayo Terán, Joselyn Maritza Vargas Paladines, Diana Aracely Sánchez Alquina.