

Rethinking Patient Protection and Legal Accountability in Artificial Intelligence Assisted Orthopedic Surgery



Arief Budiono ^{a,*}, Clarizze Yvoine Mirielle ^b, Achmadi ^a, Mohammad Indra Bangsawan ^a, Siti Soekiswati ^a

^a Faculty of Law, Universitas Muhammadiyah Surakarta, Sukoharjo, Indonesia.

^b Université de la Rochelle, La Rochelle, France.

* Corresponding Author: ab368@ums.ac.id

ARTICLE INFO

Article history

Received: February 18, 2026

Revised: August 18, 2026

Accepted: August 25, 2026

Keywords

Artificial Intelligence;

Orthopedic Policy;

Patient;

Protection;

ABSTRACT

The growing adoption of artificial intelligence in healthcare has improved clinical assessment, surgical planning, decision making, and orthopedic procedures, while simultaneously raising legal concerns regarding patient safety, professional responsibility, personal data protection, and accountability for technology supported clinical decisions. This study examines the adequacy of legal protection for patients receiving AI assisted orthopedic surgical services in Indonesia and develops a regulatory framework that strengthens patient rights and legal certainty. The study applies an empirical legal research method through observation and in-depth interviews, complemented by an analysis of relevant laws and regulations governing healthcare services, medical practice, digital technology, and patient protection. The findings reveal three main issues, first, the Indonesian legal framework does not specifically regulate the use of AI in clinical decision making, particularly when AI contributes to medical errors or patient harm. Second, existing regulations do not clearly allocate legal and professional responsibility among physicians, healthcare institutions, and technology developers involved in AI assisted orthopedic surgery. Third, Indonesia requires an integrated regulatory framework that establishes clear standards for professional accountability, informed consent, patient safety, clinical supervision, cybersecurity, personal data protection, and electronic medical records to ensure that AI assisted orthopedic surgery operates safely, transparently, accountably, and consistently with patients' rights.



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Introduction

The role of Artificial Intelligence (AI) in the medical sector emerges in image analysis and diagnosis.¹ For instance, the use of AI in detecting lung cancer² and

¹ Kinga Flaga Gieruszyńska, 'The Use of Artificial Intelligence in Psychiatric Treatment and the Protection of Patients' Privacy', *Procedia Computer Science*, 207 (2022), 3691–3702 <https://doi.org/10.1016/j.procs.2022.09.429>

² A. Ferro and others, 'Clinical Applications of Radiomics and Deep Learning in Breast and Lung Cancer: A Narrative Literature Review on Current Evidence and Future Perspectives', *Critical Reviews in Oncology/Hematology*, 2024, 203 <https://doi.org/10.1016/j.critrevonc.2024.104479>

detecting breast cancer.³ Apart from increasing diagnostic accuracy, it also significantly decreases the time needed to complete the reporting process.⁴ AI has shown a great potential in accelerating pathological analysis, accelerating the creation of new medicine, and supporting the development of effective treatment strategies.⁵ This advancement has substantially increased clinical efficiency and decreased costs. The integration of AI in orthopedic surgery⁶ was carried out through the increase in sustainable analysis. With AI, there is a rapid progress in data storage, the development of innovation, and the optimization of special algorithm in orthopedic surgery by technical experts.⁷

The AI system has become even more integral in the practice of orthopedic surgery. Aside from the challenges that are attached to the field of complex anatomic structure and demands for high precision,⁸ AI can quickly change the paradigm of traditional surgery, especially in the pre-surgery planning, intraoperative navigation, and management of post-surgery treatment.⁹ Findings show that legal regulations in Indonesia have a significant gap when faced with that,¹⁰ which encompasses the lack of specific regulations on the verification of medical algorithms, the standard of clinical validation of AI products in orthopedic surgery, and the algorithmic audit mechanism that leads to the

³ Riccardo Oliva and others, 'Artificial Intelligence for the Assessment of Peritoneal Carcinomatosis during Diagnostic Laparoscopy for Advanced Ovarian Cancer', *International Journal of Gynecological Cancer*, In press. In press (2026) <https://doi.org/10.1016/j.ijgc.2026.104814>

⁴ Amos Grünebaum, Joachim Dudenhausen and Frank A. Chervenak, 'Clinical Artificial Intelligence Competence in Obstetrics and Gynecology: Patient Safety, Physician Accountability, and Responsible Use', *American Journal of Obstetrics and Gynecology*, ahead of p. ahead of print (2026) <https://doi.org/10.1016/j.ajog.2026.06.011>

⁵ G. Heilemann and others, 'Ultra-fast, One-click Radiotherapy Treatment Planning Outside a Treatment Planning System', *Physics and Imaging in Radiation Oncology*, 33 (2025) <https://doi.org/10.1016/j.phro.2025.100724>

⁶ A. Budiono, Ayesha Ngestiningrum, and others, 'Legal Protection Policy for Obstetricians-Gynecologists in Cases of Maternal, Perinatal, and Neonatal Mortality Title', *Jurnal Hukum Novelty*, 14 (2023), 1–18 <https://doi.org/10.26555/novelty.v14i1.a25637>

⁷ Seth Warren, Lauren M. Christie and Steven R. Cooperman, 'Trends in Artificial Intelligence Research within Podiatric and Orthopedic Foot and Ankle Literature: A Bibliometric Analysis', *Foot & Ankle Surgery: Techniques, Reports & Cases*, 6.2 (2026) <https://doi.org/10.1016/j.fastrc.2026.100626>

⁸ Thomas Doss and others, 'Eliminating Nonvalue-Added Tasks in Health Care: Artificial Intelligence in the Orthopedic Office', *Journal of Hand Surgery Global Online*, 8.3 (2026) <https://doi.org/10.1016/j.jhsg.2026.100992>

⁹ Yanic Ammann and others, 'Artificial Intelligence in Visceral Surgery: A Comprehensive Narrative Review and Future Outlook', *Heliyon*, 12.13 (2026) <https://doi.org/10.1016/j.heliyon.2026.e45165>

¹⁰ Hartotok Hartotok and others, 'Stunting Prevention Policy as a Form of Child Health Rights Legal Protection', *Open Access Macedonian Journal Medical Sciences*, 9 (2021), 1218–23 <https://doi.org/10.3889/oamjms.2021.7254>

emergence of risks to legal uncertainty for patients, health workers, and service providers that depend on AI recommendations.¹¹

Researchers emphasize the urgency of formulating legal protection to protect patient safety and rights.¹² Evaluation in Asia of 117 anterior and posterior knee osteoarthritis surgeries, it is known that the accuracy reaches 35%, while the accuracy of senior doctors reaches 80%. In North America, it is found that the average achievement of AI is 97% sensitivity, 33% special condition, and 65% accuracy compared to senior doctors with 90%, 33%, and 76%. However, in a diagnostic study, it is found that the level of AI's accuracy is 52.1% and that of doctors' is 69.7%.¹³

Artificial Intelligence technologies, including their algorithms,¹⁴ can be used to increase diagnostic accuracy, optimize surgery planning, and adapt rehabilitation post-orthopedic surgery.¹⁵ Doctors can carry out their job more efficiently and effectively by utilizing AI in orthopedic surgery. In orthopedic diagnosis, AI has a rather great impact.¹⁶ A quick and accurate diagnosis is important to formulate a successful action plan, including identifying deformities and aiding the diagnosis of fractures, joint diseases, spinal problems, and other musculoskeletal diseases.¹⁷ The AI algorithm may examine medical images, such as X-ray, CT scan, and MRI. The usage of AI still allows the occurrence of diagnostic and surgical errors.¹⁸

¹¹ Achmadi Achmadi and others, 'The Construction of Customary Judge's Decision on Plantation Conflict Resolution from the Perspective of Huma Betang Philosophy: A Case Study in Seruyan Regency, Central Kalimantan', *Jurnal Jurisprudence*, 14.2 (2024) <https://doi.org/10.23917/jurisprudence.v14i2.6970>

¹² Lakshmana S. Das and others, 'Exploring the Role of Artificial Intelligence in Orthopedic Medical Education: A Narrative Review', *Journal of Clinical Orthopaedics and Trauma*, 69 (2025) <https://doi.org/10.1016/j.jcot.2025.103100>

¹³ K. Eskandar, 'The Role of Artificial Intelligence in Orthopedic Surgery: Current Applications and Future Perspectives—A Systematic Review of the Literature', *Revista Española de Cirugía Ortopédica y Traumatología*, 70.3 (2026), 248–57 <https://doi.org/10.1016/j.recot.2025.09.005>

¹⁴ Abdul Kadir Jaelani, Resti Dian Luthviati, Muhammad Jihadul Hayat, and others, 'The Impact of Artificial Intelligence on Taxation in the Promotion of Sustainable Supply Chains', *AIP Conference Proceedings*, 3337.1 (2026) <https://doi.org/10.1063/5.0296078>

¹⁵ Abdulhamit Misir, 'Artificial Intelligence in Orthopedic Trauma: A Comprehensive Review', *Injury*, 56.8 (2025) <https://doi.org/10.1016/j.injury.2025.112570>

¹⁶ Chengcheng Yu and others, 'Effectiveness of Artificial Intelligence-Assisted Peer Teaching in Orthopedic Clinical Education: Historical Cohort Study', *JMIR Medical Education*, 12 (2026) <https://doi.org/10.2196/87959>

¹⁷ Suleyman Utku Celik and others, 'Artificial Intelligence in General Surgery: A National Survey on Knowledge, Utilization, and Future Expectations', *Surgery*, 196 (2026) <https://doi.org/10.1016/j.surg.2026.110308>

¹⁸ Mariano E. Giménez and others, 'Future of Robotics and Integration of Artificial Intelligence: Toward Computer-Assisted Surgery and the Real Democratization of Surgical Care', *Surgical Oncology Clinics of North America*, 35.3 (2026), 433–46 <https://doi.org/10.1016/j.soc.2025.12.003>

Thus, there is a need to formulate legal protection for patients and policies on the ethical and safe implementation of AI in orthopedic practices.¹⁹

In Indonesia, this research is according to the *Asta Cita* of the Head of the State, especially point 4, namely strengthening human resources, science, technology, education, health, sports achievements, gender equality, as well as the strengthening of the roles of women, youth, and people with disabilities, especially the development of human resources, science, and health.²⁰ This research discusses point 16 of the Sustainable Development Goals, namely Peace, Justice and Strong Institution in providing legal protection for orthopedic surgery patients. There is a need for in-depth research to formulate policies on patient protection and the safe and ethical implementation of artificial intelligence in orthopedic practices. From the description above, several issues that will be discussed in this research are: (1) finding and describing legal protection policies for orthopedic patients in AI technology-based orthopedic surgery, and (2) formulating an ideal legal protection for orthopedic patients in AI technology-based orthopedic surgery services.

Research Method

This study employed an empirical legal research method, also known as non-doctrinal legal research,²¹ to examine the relationship between legal norms and their practical implementation in healthcare services.²² Empirical legal research enables a systematic assessment of how legal rules operate in practice and how institutional, professional, technological, and social conditions influence their implementation.²³ The study adopted a qualitative research design to investigate legal protection for patients receiving orthopedic healthcare services involving artificial intelligence.²⁴ The empirical approach treated law as an observable phenomenon and examined how existing legal principles and regulatory

¹⁹ Jonathan J. Huang and others, 'Comparing the Readability of Carpal Tunnel Patient Information between American Academy of Orthopedic Surgeons' Orthoinfo and Artificial Intelligence', *Hand Surgery and Rehabilitation*, 45.2 (2026) <https://doi.org/10.1016/j.hansur.2026.102592>

²⁰ Sukanto Satoto and others, 'Revitalization of Village-Owned Enterprises to Strengthen the Community Economy in Indonesia: Between Policy and Prosperity', *Jambe Law Journal*, 7.2 (2024), 509–37 <https://doi.org/10.22437/home.v7i2.364>

²¹ Wafda Vivid Izziyana and others, 'Health Insurance for Indonesian Migrant Workers', *Medico-Legal Update*, 19.1 (2019), 188–192 <https://doi.org/10.5958/0974-1283.2019.00038.0>

²² Sik Sumaedi and others, 'Indonesian Public Healthcare Service Institution's Patient Satisfaction Barometer (IPHSI-PSB)', *International Journal of Productivity and Performance Management*, 65.1 (2016), 25–41 <https://doi.org/10.1108/IJPPM-07-2014-0112>

²³ Julio Torales and others, 'Chiles v. Salazar and the Legal Determinants of Health: Judicial Decision-Making as a Geopsychiatric Pathway', *Geopsychiatry*, 4 (2026) <https://doi.org/10.1016/j.geopsy.2026.100108>

²⁴ Jian Song and others, 'Artificial Intelligence in Orthopedics: Fundamentals, Current Applications, and Future Perspectives', *Military Medical Research*, 12.1 (2025), 42 <https://doi.org/10.1186/s40779-025-00633-z>

arrangements operate within clinical practice.²⁵ This approach was particularly relevant because the application of artificial intelligence in orthopedic services, including clinical assessment, diagnosis, surgical planning, and medical decision making, may generate risks associated with inaccurate recommendations, professional responsibility, patient safety, and legal accountability.

The study also employed conceptual and comparative approaches. The conceptual approach examined artificial intelligence as an emerging component of orthopedic healthcare that requires appropriate legal principles to protect patients and clarify the responsibilities of relevant actors.²⁶ The comparative approach examined regulatory frameworks and practices in Malaysia and Uzbekistan to identify legal principles that could inform regulatory development in Indonesia. The comparison focused on human oversight, physician responsibility for final clinical decisions, transparency, informed consent, patient safety, and accountability for artificial intelligence applications in healthcare.

Primary data were collected through in-depth interviews and Focus Group Discussions using structured interview guidelines. Purposive sampling identified participants based on their expertise, professional responsibilities, and direct involvement in orthopedic healthcare and digital technology. Participants included orthopedic patients, orthopedic physicians, healthcare professionals, healthcare facility managers, law enforcement officials, legal experts, and information technology specialists.²⁷

The study complemented primary data with a literature review and legal mapping of relevant legislation, policies, legal documents, and regulatory practices concerning healthcare, patient protection, artificial intelligence, and digital health governance. Interview and Focus Group Discussion data were transcribed, classified, interpreted, and analyzed qualitatively.²⁸ The analysis integrated empirical findings with conceptual and comparative legal analysis to identify regulatory gaps and formulate an appropriate framework for Indonesia. The proposed framework emphasizes patient safety, professional accountability, informed consent, human clinical oversight, personal data protection,

²⁵ Katérine Aminot, Tara J. Ryan and Alicia Nijdam-Jones, 'Examining the Court's Perspective: Legal Professionals' Perceptions and Preferences of Expert Testimony', *International Journal of Law and Psychiatry*, 108 (2026) <https://doi.org/10.1016/j.ijlp.2026.102248>

²⁶ S Shamtej Singh Rana, Jacob S. Ghahremani and Ronald A. Navarro, 'The Future of Food and Drug Administration Regulation on Artificial Intelligence-Enabled Medical Devices: An Orthopedic Surgeon's Guide', *Journal of Shoulder and Elbow Surgery*, 34.1 (2025), 260–64 <https://doi.org/10.1016/j.jse.2024.08.008>

²⁷ Cody C. Wyles and others, 'Reporting Guidelines for Artificial Intelligence Use in Orthopaedic Surgery Research', *The Journal of Arthroplasty*, 40.10 (2025) <https://doi.org/10.1016/j.arth.2025.05.093>

²⁸ Alexander C. Wagenaar and Scott Burris, 'Public Health Law Research: Theory and Methods', *Journal of Nursing Regulation*, 4.4 (2014), 60 [https://doi.org/10.1016/S2155-8256\(15\)30116-2](https://doi.org/10.1016/S2155-8256(15)30116-2)

cybersecurity, and responsible artificial intelligence governance in orthopedic healthcare services.²⁹

Results and Discussion

Legal Protection Policy for Patients in AI Technology-Based Orthopedic Surgical Services

The utilization of AI in orthopedic surgical services develop quicker than the formulation of the regulations that govern it.³⁰ Even though the Indonesian positive law has regulated the establishment of health services, medical practices, hospitals, personal data protection, and electronic medical records, there are regulations that specifically govern the use of AI in the process of making clinical decisions.³¹ This void of norms leads to uncertainty regarding the standard in using AI, the monitoring mechanism, the division of legal responsibilities, as well as legal protection for patients in case of system errors that lead to losses.³² Considering that orthopedic surgical services are high-risk medical actions, AI utilization without adequate regulations may potentially lead to legal disputes due to algorithmic errors, software failures, and the lack of doctors' supervision.³³ Therefore, legal protection policies for orthopedic patients need to be analyzed through analyses on the blurriness of the subject, the regulations on informed consent, and the burden of proof in disputes in AI-based orthopedic surgical services.³⁴

The construction of legal liability in AI-based orthopedic surgical services still has not provided certainty regarding legal subjects that are responsible for patients' losses.³⁵ The Indonesian positive law still places doctors and hospitals as

²⁹ A. Budiono, G. O. Alba, and others, 'Digital Defense Drives Economic Growth in Indonesia and Uzbekistan', *Journal of Sustainable Development and Regulatory Issues*, 3.2 (2025), 147–149 <https://doi.org/10.53955/jsderi.v3i2.47>

³⁰ Andrew P. Kurmis and Jamie R. Ianunzio, 'Artificial Intelligence in Orthopedic Surgery: Evolution, Current State and Future Directions', *Arthroplasty*, 4.1 (2022) <https://doi.org/10.1186/s42836-022-00112-z>

³¹ Article I N Press, *Npj Digital Medicine Article in Press The Role of Agentic Artificial Intelligence in Healthcare: A Scoping Review* TIES, 2026.

³² Sawsan Abuhammad, 'Artificial Intelligence in Nursing Education: A Contemporary Issue for Ethical, Safe, and Human-Centered Curriculum Reform', *Nurse Education Today*, 167 (2026) <https://doi.org/10.1016/j.nedt.2026.107310>

³³ Zhijian Chen and others, 'A Retrospective Study on the Impact of Two Anesthesia Methods on Postoperative Outcomes in Elderly Patients Undergoing Lower Limb Orthopedic Surgery', *Geriatrics & Gerontology International*, 26.1 (2026), e70320 <https://doi.org/10.1111/ggi.70320>

³⁴ Xinlong Diao and others, 'A Review of the Application of Artificial Intelligence in Orthopedic Diseases', *Computers, Materials and Continua*, 78.2 (2024), 2617–65 <https://doi.org/10.32604/cmc.2024.047377>

³⁵ Sara Gerke, David A Simon and Benjamin R Roman, 'Liability Risks of Ambient Clinical Workflows With Artificial Intelligence for Clinicians, Hospitals, and Manufacturers', *JCO Oncology Practice*, 22.3 (2025), 357–61 <https://doi.org/10.1200/OP-24-01060>

parties that are responsible for establishing health services.³⁶ Meanwhile, AI is positioned as a technological instrument that helps the diagnostic process, surgical planning, and clinical data analysis.³⁷ AI's position as a software makes that system still incapable of becoming a legal subject that can independently be asked for responsibility when producing wrong recommendations due to *algorithmic bias*, errors in data processing, and system failure.³⁸ This condition shows the existence of a regulatory void in the construction of responsibility in AI-based health services.³⁹

This blurriness leads to difficulties in determining the parties that must bear the legal liability in case the AI recommendations become one of the foundations for making medical decisions.⁴⁰ Patient losses may be sourced from doctors' negligence in conducting supervision, algorithmic and programming errors, the quality of data for system training, and the software failure that exists beyond the control of medical workers.⁴¹ This issue becomes even more apparent in the implementation of *informed consent*, as applicable regulations do not always oblige doctors to explain the level of AI's involvement, the chance for algorithmic failures, the division of function between doctors and the AI system,⁴² as well as the risk of medical record data leakage due to disturbances to the cybersecurity.⁴³ As a consequence, patient consent is not fully based on adequate information on the risks of using AI in orthopedic surgical services.

³⁶ Ratih Dheviana Puru Hitaningtyas, M. Hadi Subhan and Nurwahjuni, 'Deactivation of Health Security Participation as a Form of Unlawful Act (Legal Reasoning of the Judicial Decision in the Khalimah vs BPJS Case', *Jurnal Jurisprudence*, 14.2 (2024), 277–95 <https://doi.org/10.23917/jurisprudence.v14i2.6460>

³⁷ Frances Lee and Shing Wai Wong, 'Surgical Education Reimagined: The Convergence of Learning Theories and Artificial Intelligence', *BMC Medical Education*, 26.1 (2026) <https://doi.org/10.1186/s12909-025-08039-0>

³⁸ Syed Ibad Ali, 'Artificial Intelligence and the Law: Human Rights, Justice Systems, and Governance in the Age of Autonomous Decision-Making', *IJAMRED-International Journal of Advanced Multidisciplinary Research and Educational Development*, 2.1 (2026). <https://ijamred.com/volume2/issue1/IJAMRED-V2I1P35.pdf>

³⁹ Dona Budi Kharisma, Agus Yudha Hernoko and Prawitra Thalib, 'Artificial Intelligence in Healthcare: Risk Analysis and Regulatory Issues', *The Theory and Practice of Legislation*, 14.1 (2026), 46–62 <https://doi.org/10.1080/20508840.2025.2576415>

⁴⁰ Marcel Levi, 'Artificial Intelligence in Diagnostics and Medical Decision Making', *European Journal of Internal Medicine*, Online ahead of print (2026) <https://doi.org/10.1016/j.ejim.2026.107056>

⁴¹ Rohan Khera, Melissa A Simon and Joseph S Ross, 'Automation Bias and Assistive AI: Risk of Harm From AI-Driven Clinical Decision Support', *JAMA*, 330.23 (2023), 2255–57 <https://doi.org/10.1001/jama.2023.22557>

⁴² Ben Van Calster and others, 'Evaluation of Performance Measures in Predictive Artificial Intelligence Models to Support Medical Decisions: Overview and Guidance', *The Lancet Digital Health*, 7.12 (2025) <https://doi.org/10.1016/j.landig.2025.100916>

⁴³ M Chau, M G Rahman and T Debnath, 'From Black Box to Clarity: Strategies for Effective AI Informed Consent in Healthcare', *Artificial Intelligence in Medicine*, 167 (2025), 103169 <https://doi.org/10.1016/j.artmed.2025.103169>

The utilization of *Artificial Intelligence* in orthopedic surgical services also leads to the emergence of the burden of proof issue in case of medical disputes.⁴⁴ The evidencing system of the Indonesian civil law places the party that files the lawsuit as that which is obliged to prove his argument.⁴⁵ As a consequence, patients must prove the existence of law-violating actions or negligence that leads to patient losses. An issue arises when surgical actions involve AI as a system that supports the making of clinical decisions.⁴⁶ Patients are not only required to prove the existence of losses in the form of deformities, paralyses, or surgical failures, but they must also prove the source of error that leads to the occurrence of such errors.⁴⁷ Such a condition places patients in a highly difficult position to prove (*probatio diabolica*), as the information on the process of how AI works,⁴⁸ the data used, and the decision-making mechanism are in the hands of doctors, hospitals, and technological developers.⁴⁹

The difficulty to prove errors become even greater when patient losses are suspected to occur from an interaction between human error and system error.⁵⁰ Doctors may opine that the medical action carried out is already according to the professional standards by referring to AI recommendations, but technological developers may state that the system has worked according to the specifications; thus, errors originate from inaccurate usage.⁵¹ On the other hand, hospitals only have the role of health service facility providers. These different interests make patients face obstacles in obtaining evidence that may explain the cause of the occurrence of losses in an objective manner. This condition shows that the proving

⁴⁴ Faraz Farhadi and others, 'Applications of Artificial Intelligence in Orthopaedic Surgery', *Frontiers in Medical Technology*, Volume 4- (2022) <https://doi.org/10.3389/fmedt.2022.995526>

⁴⁵ Tunggul Anshari Setia Negara and others, 'The Confrontational Role of the Constitutional Court's Decisions in the Legislative Process', *International Journal of Criminal Justice Sciences*, 17.1 (2022), 185–198 <https://doi.org/10.5281/zenodo.4756099n>

⁴⁶ Lu Wang and others, 'Artificial Intelligence in Clinical Decision Support Systems for Oncology', *International Journal of Medical Sciences*, 20.1 (2023), 79–86 <https://doi.org/10.7150/ijms.77205>

⁴⁷ Michael R. MacIntyre and others, 'Ethical Considerations for the Use of Artificial Intelligence in Medical Decision-Making Capacity Assessments', *Psychiatry Research*, 328 (2023) <https://doi.org/10.1016/j.psychres.2023.115466>

⁴⁸ A. Hariri, B. Babussalam and Muhammad Aunurrochim Mas'ad Saleh, 'Between Legality and Justice: A Critical Study of the Supreme Court's Judicial Reasoning in Dispute of the Awyu Customary Forest', *Jurnal Jurisprudence*, 15.2 (2025), 146–176 <https://doi.org/10.23917/jurisprudence.v15i2.11442>

⁴⁹ Sebastian Griewing and others, 'Physicians' Perception Of The Utility Of Artificial Intelligence To Align Medical Decisions With Current Recommendations And Evidence', *International Journal of Gynecological Cancer*, 35.2 (2025) <https://doi.org/10.1016/j.ijgc.2024.101563>

⁵⁰ Georgy Lebedev and others, 'Technology of Supporting Medical Decision-Making Using Evidence-Based Medicine and Artificial Intelligence', *Procedia Computer Science*, 176 (2020), 1703–12 <https://doi.org/10.1016/j.procs.2020.09.195>

⁵¹ Michelle M Mello and Neel Guha, 'Health Law, Ethics, and Human Rights Understanding Liability Risk from Using Health Care Artificial Intelligence Tools', *New Engl J Med*, 390 (2024), 271. <https://www.nejm.org/doi/10.1056/NEJMhle2308901>

mechanism in conventional medical disputes has not fully been able to answer the characteristics of disputes that involve AI technologies.⁵²

The lack of regulations on the special proving mechanism in AI-based health services may potentially decrease the effectiveness of legal protection for patients.⁵³ This happens even though there is log system data, records of algorithmic activities, as well as the software validation process. So long as the burden of proof is fully in the hands of patients, dispute resolution will depend on victims' capability in obtaining technical proof that is, in practice, difficult to access, as it is in the control of service providers and technological developers.⁵⁴ This situation shows the need for the renewal of legal policies which provide a balanced position of the parties in the evidencing process, so that patient rights to obtain justice is not inhibited by technological complexity that is used in AI-based orthopedic surgical services.

Artificial Intelligence in Orthopedic Surgery Policy: Rethinking Patient Protection and Accountability

Orthopedic surgical services in Indonesia are still faced with the limited number of orthopedic specialist doctors compared to people's needs for services.⁵⁵ This condition impacts the lack of equal access to health services, especially in areas that have limited medical worker resources. The utilization of AI becomes one of the alternatives to help accelerate the analysis of medical images, support diagnostic enforcement, formulate surgical planning, as well as produce clinical recommendations in a more efficient manner.⁵⁶ The existence of AI is not supposed to take over the role of orthopedic doctors, but increase service effectiveness through a system that supports the taking of clinical decisions.⁵⁷ Doctors still hold the professional authority to conduct verification, supervision, and determine the most appropriate medical actions based on patient conditions. Thus, the usage of AI is still under the monitoring of competent medical workers.

⁵² Sebastian Schleidgen and Orsolya Friedrich, 'Artificial Intelligence in Medicine: An Ethical and Legal Review', *European Journal of Internal Medicine*, In Press. In Press (2026) <https://doi.org/10.1016/j.ejim.2026.107172>

⁵³ Jon Truby and others, 'A Sandbox Approach to Regulating High-Risk Artificial Intelligence Applications', *European Journal of Risk Regulation*, 13.2 (2022), 270–94 <https://doi.org/DOI:10.1017/err.2021.52>

⁵⁴ Raid Abujebbeh and Mohammad M. Alnaeem, 'Artificial Intelligence in Nursing Informatics: A Systematic Review of Care Planning, Workflow Optimization, and Health Outcomes', *Applied Nursing Research*, 90 (2026) <https://doi.org/10.1016/j.apnr.2026.152113>

⁵⁵ Shuroug A Alowais and others, 'Revolutionizing Healthcare: The Role of Artificial Intelligence in Clinical Practice', *BMC Medical Education*, 23.1 (2023), 689 <https://doi.org/10.1186/s12909-023-04698-z>

⁵⁶ Rahim Hirani and others, 'Artificial Intelligence and Healthcare: A Journey through History, Present Innovations, and Future Possibilities', *Life*, 14.5 (2024) <https://doi.org/10.3390/life14050557>

⁵⁷ M Isgut and others, 'Systematic Review of Advanced AI Methods for Improving Healthcare Data Quality in Post COVID-19 Era', *IEEE Reviews in Biomedical Engineering*, 16 (2023), 53–69 <https://doi.org/10.1109/RBME.2022.3216531>

This condition requires a legal protection formulation that may accommodate technological development as well as guarantee patient safety.⁵⁸ The developed legal policies must give certainty on the limits to AI utilization, the division of responsibility between doctors, hospitals, and technological developers, as well as a supervision mechanism on the use of AI in orthopedic surgical services.⁵⁹ This formulation needs to be arranged based on the principles of legal certainty, benefit, and justice,⁶⁰ so that the use of AI may increase the quality of health services without decreasing the protection of patient rights. Based on this, the ideal legal protection concept is directed to the strengthening of the informed consent mechanism, the clarifying of legal liability construction, and the formation of compensation schemes for patients experiencing losses, as well as the strengthening of data security and electronic system safety in establishing AI-based orthopedic surgical services.⁶¹ The ideal legal protection formulation for patients of AI-based orthopedic surgery is shown in the position orthopedic patients at the center of legal protection in surgical services that incorporate artificial intelligence.

The use of artificial intelligence in orthopedic care should improve patient safety, clinical accuracy, and healthcare quality while preserving patient autonomy and preventing technological risks from being unfairly transferred to patients. Effective legal protection requires healthcare providers to secure personal health data and electronic medical records and to maintain transparency regarding the use of artificial intelligence, the origin and processing of clinical data, the limitations of algorithmic recommendations, and foreseeable technological risks.⁶² The increasing role of artificial intelligence in diagnosis, surgical planning, and clinical decision making also requires a more specific model of informed consent. Healthcare professionals should provide patients with clear, accurate, and understandable information concerning the function of artificial intelligence, possible algorithmic errors, cybersecurity threats, risks of

⁵⁸ Igor Vyacheslavovich Buzaev and others, 'Artificial Intelligence: Neural Network Model as the Multidisciplinary Team Member in Clinical Decision Support to Avoid Medical Mistakes', *Chronic Diseases and Translational Medicine*, 2.3 (2016), 166–72 <https://doi.org/10.1016/j.cdtm.2016.09.007>

⁵⁹ Kavitha Palaniappan, Elaine Y Lin and Silke Vogel, 'Global Regulatory Frameworks for the Use of Artificial Intelligence (AI) in the Healthcare Services Sector', *Healthcare*, 2024, 562 <https://doi.org/10.3390/healthcare12050562>

⁶⁰ Abdul Kadir Jaelani, Resti Dian Luthviati, Muhammad Jihadul Hayat, and others, 'Digital Transformation Strategy for Achieving Judicial Transparency', *AIP Conference Proceedings*, 3337.1 (2026) <https://doi.org/10.1063/5.0296077>

⁶¹ Ricardo Bastos and others, 'Generative Artificial Intelligence as a Research Partner in Orthopaedics: State of the Art', *Journal of ISAKOS*, 18 (2026) <https://doi.org/10.1016/j.jisako.2026.101126>

⁶² Shuang Gao, Daquan Yan and Long He, 'Comment on Artificial Intelligence versus Orthopedic Surgeons as an Orthopedic Consultant in the Emergency Department', *Injury*, 56.11 (2025) <https://doi.org/10.1016/j.injury.2025.112467>

data breaches, and the respective roles of physicians and intelligent systems before patients consent to medical procedures.⁶³

The human oversight also constitutes an essential safeguard in orthopedic surgery involving artificial intelligence. Artificial intelligence should support clinical judgment rather than replace the professional authority of physicians.⁶⁴ Senior or appropriately certified physicians should retain final responsibility for diagnoses, treatment recommendations, and surgical decisions. They should independently assess, verify, validate, and document recommendations generated by artificial intelligence before incorporating them into clinical practice.⁶⁵ This model of human oversight requires a clear allocation of responsibility among the actors involved in delivering technology supported healthcare.

Physicians should bear responsibility for negligence arising from professional judgment and clinical decisions, while healthcare institutions should assume responsibility for institutional governance, technological implementation, service standards, and system supervision.⁶⁶ Artificial intelligence developers and technology providers should bear responsibility for harm attributable to defects in system design, algorithms, programming, data processing, or technological performance. Such an allocation prevents uncertainty when patient harm results from interactions between clinical decisions and technological failures.⁶⁷

The meaningful patient protection depends on an accessible compensation mechanism supported by a comprehensive accountability framework. A dedicated insurance mechanism or no-fault compensation scheme may provide timely remedies when patients experience harm associated with artificial intelligence assisted orthopedic procedures without requiring proof of professional negligence as a prerequisite for every claim.⁶⁸ However, such a mechanism should preserve

⁶³ Michael Knop and others, 'Human Factors and Technological Characteristics Influencing the Interaction of Medical Professionals With Artificial Intelligence-Enabled Clinical Decision Support Systems: Literature Review', *JMIR Human Factors*, 9.1 (2022) <https://doi.org/10.2196/28639>

⁶⁴ Raju Vaishya and others, 'Integrating Artificial Intelligence into Orthopedics: Opportunities, Challenges, and Future Directions', *Journal of Hand and Microsurgery*, 17.4 (2025) <https://doi.org/10.1016/j.jham.2025.100257>

⁶⁵ Aanuoluwapo Clement David-Olawade, Adewoyin A. Osonuga and David B. Olawade, 'Nurses' Knowledge, Attitudes, Literacy, Anxiety, and Readiness towards Artificial Intelligence in Clinical Practice: An International Scoping Review', *Applied Nursing Research*, 91 (2026) <https://doi.org/10.1016/j.apnr.2026.152135>

⁶⁶ Akram Y. Sarhan, 'A Privacy-Aware Artificial Intelligence Framework for Crowd Monitoring and Dispatching Using Wearable Internet of Things', *Engineering Applications of Artificial Intelligence*, 181.3 (2026) <https://doi.org/10.1016/j.engappai.2026.115516>

⁶⁷ Anh L. Huynh and others, 'Applications of Artificial Intelligence-Based Conversational Agents in Healthcare: A Systematic Umbrella Review', *International Journal of Medical Informatics*, 207 (2026) <https://doi.org/10.1016/j.ijmedinf.2025.106204>

⁶⁸ Julien Bardou-Jacquet and Jérôme Murgier, 'Predictive Artificial Intelligence Could Positively Influence Orthopedic Practices and Be More Widely Integrated by Applying It with Greater

the patient's right to pursue appropriate legal remedies when evidence establishes negligence or another basis of liability. An effective legal framework should therefore integrate data security, transparency, informed consent specific to the use of artificial intelligence, mandatory human oversight, clearly allocated responsibility, and accessible compensation. By connecting preventive protection with accountability and remedial mechanisms, this framework allows technological innovation to advance orthopedic healthcare while maintaining human clinical judgment, patient safety, legal certainty, and respect for patients' fundamental rights.⁶⁹

There is no obligation to prove the element of error from AI developers. However, it is enough to prove the existence of losses and a causal relationship with the use of such technologies. This construction still maintains doctors' professional responsibility in conducting the supervision of AI usage, as well as achieve a more proportional division of responsibility between doctors, hospitals, and technological developers in giving legal certainty and more effective protection for patients. An ideal legal protection formulation needs to apply the strict liability doctrine to vendors or Artificial Intelligence technological developers,⁷⁰ if patient losses are proven to originate from design flaws, algorithmic errors, software failures, or systemic flaws in the system used in orthopedic surgical services.⁷¹ The application of this doctrine is based on the characteristics of AI technologies that are designed, developed, and controlled by developers. Thus, the risks that occur due to technological flaws become part of their responsibility.

In the strict liability construction, patients are not burdened with the obligation to prove the existence of an element of fault from vendors. However, it is enough to prove the existence of losses as well as the causal relationship between systemic flaws and the losses experienced.⁷² Such regulations provide legal certainty as well as strengthen legal protection for patients, because the burden of proof that has so far become a hindrance in AI-based health service disputes may be decreased

Transparency and Regulation from Learned Societies', *Orthopaedics & Traumatology: Surgery & Research*, 111.3 (2025) <https://doi.org/10.1016/j.otsr.2025.104225>

⁶⁹ Chuwei Tian and others, 'Artificial Intelligence in Orthopaedic Trauma', *EngMedicine*, 1.2 (2024) <https://doi.org/10.1016/j.engmed.2024.100020>

⁷⁰ Sarjiyanto Sarjiyanto and others, 'The Role of Community Empowerment as Mediator on the Relationship Between Psychological, Social, and Financial Capital on Rural Community Well-Being', *Journal of Population and Social Studies*, 34 (2026), 99–117 <https://doi.org/10.25133/JPSSv342026.006>

⁷¹ Baris Soyer and Andrew Tettenborn, 'Artificial Intelligence and Civil Liability—Do We Need a New Regime?', *International Journal of Law and Information Technology*, 30.4 (2022), 385–97 <https://doi.org/10.1093/ijlit/eaad001>

⁷² Shu Li and Michael Faure, 'The Revised Product Liability Directive: A Law and Economics Analysis', *Journal of European Tort Law*, 15.2 (2024), 140–71 <https://doi.org/doi:10.1515/jetl-2024-0010>

without eliminating the professional responsibilities of doctors and hospitals according to each of their authorities. The formulation of an ideal legal protection must declare that the use of Artificial Intelligence in orthopedic surgical services does not shift doctors' professional responsibilities as the makers of clinical decisions.⁷³ AI only functions to provide recommendations based on data processing, while validation of such recommendations still becomes the obligation of doctors who have competencies in the orthopedic field.⁷⁴

In the condition where AI produces wrong recommendations for bone cutting due to algorithmic bias,⁷⁵ doctors who still conduct such actions without undergoing verification may still be asked for responsibility as they neglect their supervision function (automation bias).⁷⁶ On the contrary, vendors or technological developers still have responsibility based on the strict liability doctrine if such errors are proven to originate from algorithmic flaws, system design, or the software that they developed.⁷⁷ Such a construction of liability creates a proportional division of responsibilities, where doctors are responsible for negligence in conducting their professional obligations, while vendors are responsible for the risks that occur due to the flaws in the AI technology that they produced and marketed.

The ideal legal protection formulation needs to adopt a vicarious liability construction between doctors, hospitals, and artificial intelligence developers in establishing orthopedic surgical services. This construction is based on the reality that AI-based services are a result of the involvement of various interrelated parties. Thus, the losses that patients experience do not always originate from one party. Hospitals have the responsibility as the establisher of health services that provide the system and guarantee the suitability for its use. Doctors are responsible for the implementation of medical actions according to professional standards and supervisory obligations, while AI developers are responsible for the safety, reliability, and quality of the produced system. Through the vicarious liability mechanism, patients have the right to quickly obtain compensation

⁷³ Mario Verdicchio and Andrea Perin, 'When Doctors and AI Interact: On Human Responsibility for Artificial Risks', *Philosophy & Technology*, 35.1 (2022), 11 <https://doi.org/10.1007/s13347-022-00506-6>

⁷⁴ Emre Sezgin, 'Artificial Intelligence in Healthcare: Complementing, Not Replacing, Doctors and Healthcare Providers', *Digital Health*, 9 (2023), 1–5 <https://doi.org/10.1177/20552076231186520>

⁷⁵ Abdul Kadir Jaelani, Resti Dian Luthviati, Ahmad Siboy, and others, 'Artificial Intelligence Policy in Promoting Indonesian Tourism', *Volksgeist: Jurnal Ilmu Hukum Dan Konstitusi*, 2024, 109–37 <https://doi.org/10.24090/volksgeist.v7i1.10623>

⁷⁶ Daiju Ueda and others, 'Fairness of Artificial Intelligence in Healthcare: Review and Recommendations', *Japanese Journal of Radiology*, 42.1 (2024), 3–15 <https://doi.org/10.1007/s11604-023-01474-3>

⁷⁷ Dane Bottomley and Donrich Thaladar, 'Liability for Harm Caused by AI in Healthcare: An Overview of the Core Legal Concepts', *Frontiers in Pharmacology*, 14.December (2023), 1–9 <https://doi.org/10.3389/fphar.2023.1297353>

without first proving each party's proportion of error. After patient rights have been fulfilled, the division of responsibility may be fulfilled through a regressive mechanism between Hospitals, doctors, and AI developers according to each of their levels of error and responsibility. Such a construction provides legal certainty as well as strengthens protection towards patients as the party that is most vulnerable in AI-based orthopedic surgical services.

The formation of the no-fault compensation scheme becomes one of the alternatives to strengthen legal protection for patients experiencing losses due to the use of Artificial Intelligence in orthopedic surgical services.⁷⁸ This scheme gives patients the right to obtain compensation for surgical failures originating from the failure of the AI system without first proving the existence of the doctor's element of fault in the justice process.⁷⁹ This mechanism aims to accelerate the recovery of patient rights and decrease the burden of proof that have so far become hindrances in resolving medical cases, as well as providing legal certainty on the provision of compensation. The compensation funds may be collected through the mandatory insurance scheme that is imposed on hospitals and AI technological developers as the parties that establish and obtain benefits from the usage of that system. If, in the next evaluation process, it is proven that there is negligence of doctors, hospitals, or technological developers, the resolution on the division of responsibilities may be carried out through a regressive mechanism without decreasing patient rights to obtain compensation in a quick, effective, and just manner.

The strengthening of regulations on cybersecurity and personal data protection has become an important part in the establishment of AI-based orthopedic surgical services, as the AI system processes health data that has specific and confidential characteristics, such as electronic medical records, CT-Scan results, MRI, radiography, as well as data on patients' bone structure.⁸⁰ Therefore, the establisher of health services and AI developers are obliged to apply electronic system security standards through encryption, access control, and routine security audits to prevent data leakage and misuse. This regulation also needs to prevent the use of patient medical data for commercial interests, algorithmic training, or product development without patient approval according to legal regulation stipulations and the monitoring of the Indonesian Orthopedic and Traumatology

⁷⁸ Fergus J Caskey and others, 'The High-Volume Haemodiafiltration vs High-Flux Haemodialysis Registry Trial (H4RT): A Multi-Centre, Unblinded, Randomised, Parallel-Group, Superiority Study to Compare the Effectiveness and Cost-Effectiveness of High-Volume Haemodiafiltration and High-FI', *Trials*, 23.1 (2022), 532 <https://doi.org/10.1186/s13063-022-06357-y>

⁷⁹ Ming-Chao Huang and others, 'Five-Year Results of No-Fault Compensation Related to Childbirth Injuries in Taiwan', *Taiwanese Journal of Obstetrics and Gynecology*, 61.1 (2022), 102–9 <https://doi.org/10.1016/j.tjog.2021.12.001>

⁸⁰ Bangul khan and others, 'Drawbacks of Artificial Intelligence and Their Potential Solutions in the Healthcare Sector', *Biomedical Materials & Devices*, 1.2 (2023), 731–38 <https://doi.org/10.1007/s44174-023-00063-2>

Ethics and Professionalism Council.⁸¹ Apart from that, the formation of a national electronic medical record database as mandated in Law No. 17 of 2023 on Health needs to be optimized to guarantee the continuity of medical information, increase the accuracy of clinical decision-making processes, and support the use of AI that still guarantees data security and the protection of patient rights.

Conclusion

Legal protection policies for orthopedic patients in AI-based surgical services in Indonesia has not yet provided adequate legal certainty, as there are not yet any special regulations on the use of AI in the making of clinical decisions. This legal void is reflected in the unclear construction of legal liability, the lack of optimum regulations on informed consent that accommodates AI usage, as well as the application of conventional evidencing mechanisms that places patients to have a heavy burden of proof (*probatio diabolica*). This condition shows the need to renew legal policies, so that they may provide certainty on the division of responsibilities and strengthen legal protection for patients. It is suggested that the ideal legal protection formulation needs to be manifested through the strengthening of informed consent based on AI transparency, the application of the strict liability doctrine on technological developers, the clear regulations on doctors' supervisory obligation, the formation of vicarious obligations between hospitals, doctors, and AI developers, as well as the application of the No-Fault Compensation Scheme to accelerate the fulfilment of patient rights. This formulation must also be supported by the strengthening of regulations on cybersecurity, personal data protection, and the national electronic medical record management, so that the use of Artificial Intelligence in orthopedic surgical services may run safely while providing legal certainty, as well as guaranteeing a more effective protection for patients.

Acknowledgement

This research was funded by the Directorate of Research and Community Service (DPPM), Ministry of Higher Education, Science, and Technology (Kemdiktisaintek), Republic of Indonesia, under the Fundamental Regular Research (PFR) Scheme, pursuant to Primary Contract No. 285/C3/DT.05.00/PL-BARU/2026, Contract No. 07/LL6/AL.04.03/PL-BARU/2026, and Contract No. 261.28/DRPPS/A.3-9/IV/2026. The researchers gratefully acknowledge the financial support provided for the implementation and completion of this research.

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