Journal of Cardiovascular Disease Research
ISSN: 0975-3583, 0976-2833 VOL16, ISSUE 1, 2025

Original Research Article

# Artificial Intelligence Applications in Surgical Decision-Making: A Meta-Analysis

Dr Vikram Singh Yadav[1], Dr Gulshan Kumar[*2]
1Assistant Professor SKS Hospital Medical College and Research Centre
2Associate Professor SKS Hospital Medical College and Research Centre

**Corresponding Author**
Dr Gulshan Kumar
Associate Professor SKS Hospital Medical College and Research Centre

## Abstract

AI is revolutionalising the area of decision supporting for surgeons through applied diagnosis and risk as well as outcomes prediction enhancement. This meta-analysis compiles recent works to present an understanding of the role of AI in improving the surgical outcomes. Neural networks and other kinds of machine learning have demonstrated their capacity to extend clinical skill across the range from preoperative preparation to postoperative follow-up. These technologies enhance the efficiency, effectiveness, and trends in consumption and variation in clinical judgments of patients' shift results with better patient outcomes. However, based on the above development, the following are the challenges likely to hinder adoption of the systems: ethical issues and data privacy. Stronger validation activities, collaboration between different departments, and clear rules from the respective authorities to endorse these findings are needed. From the details of this analysis, AI in surgery has been underscored as having a radical significance to the clinicians and patients by coming up with standards and policies that enhance implementation based on a theory of praxeology that has legal, ethical, and practical implications in enhancing patient care within the best implementation way. The present and future directions are, increasing the algorithmically intelligibility and implementing artificial intelligence in innovative surgical technologies.

ISSN: 0975-3583, 0976-2833 VOL16, ISSUE 1, 2025

**Keywords**: Artificial Intelligence (AI), Surgical Decision-Making, Risk Assessment Diagnostic Accuracy, Ethical Challenges

## Introduction

Recent technological advancement in Artificial Intelligence (AI) has been one of the revolutionary key drivers in solving many health issues particularly in determining surgical procedures. Technology advancement of ML, DL and neural networks has enabled the AI systems to process and analyze largeness and complexity of data in the shortest time possible. These technologies involve diagnostic and prognostic evaluation, prediction of risk, evaluation of the proposed operation plan, and forecasts of post-surgical outcomes that assist clinicians in enhancing patient care delivery. Several core issues are met by incorporating AI into the process of decision-making at the time of surgery: variability in clinical decisions, diagnostic accuracy, and utilization of resources. For instance, an AI-based tool can estimate the patient's surgical risks and the available procedural strategies besides recommending individualized treatments. However, high hurdles to utilizing AI in surgeries would still persist, especially complicating those related to ethical decision making, data privacy as well as the integrity of clinician validation. This meta-analysis examines the outcomes and bias of mdeploy of AI in decision-making within surgery, thereby giving an understanding of efficiency and obstacles.

ISSN: 0975-3583, 0976-2833 VOL16, ISSUE 1, 2025

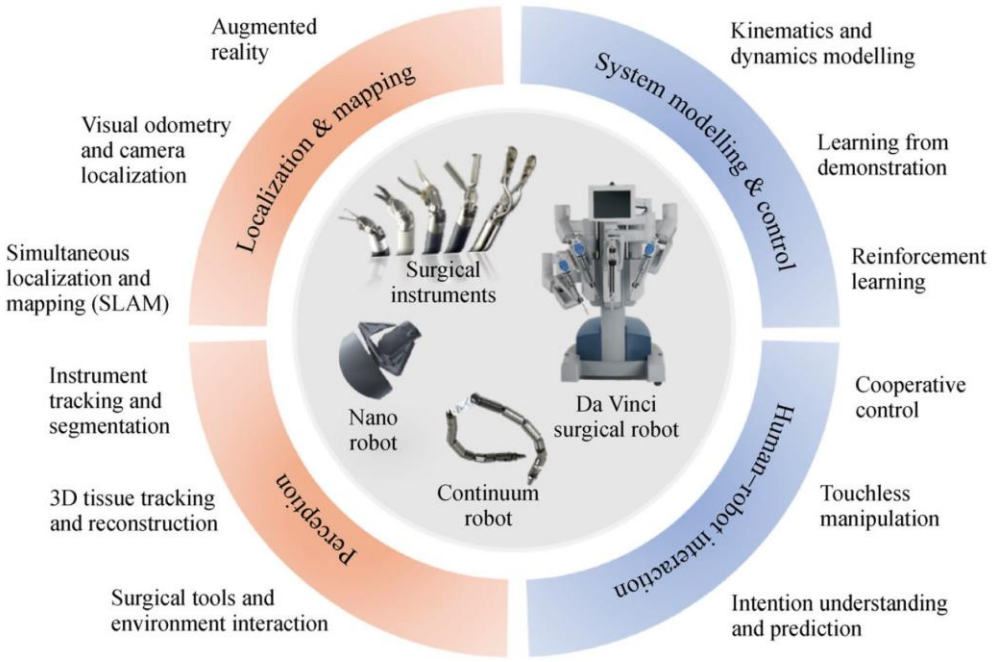


**Figure 1: AI techniques for surgical robotics**

(Source: www.imperial.ac.uk)

## Literature review

### Transformative Potential and Ethical Challenges of AI in Healthcare

According to the authors (Younis et al., 2024), artificial intelligence (AI) especially ChatGPT offers the opportunity to revolutionize Medicine and Healthcare services. Accordingly, 82 studies are categorized under eight care sectors, treatment, diagnosing, imaging, teaching, diagnosing diseases, pharmaceuticals, and improving doctor-patient communication in surgical and dental procedures. As an AI model with the capability of generating results from huge datasets, ChatGPT reduces the time spent in research thereby complementing clinical decision making. However, incorporating AI presents problem areas that regard ethics, biased data to train it, and context-based information that it may lack (Henn et al., 2021). It suggests maintaining human control while developing accurate and ethically appropriate AI deployments.

ISSN: 0975-3583, 0976-2833 VOL16, ISSUE 1, 2025

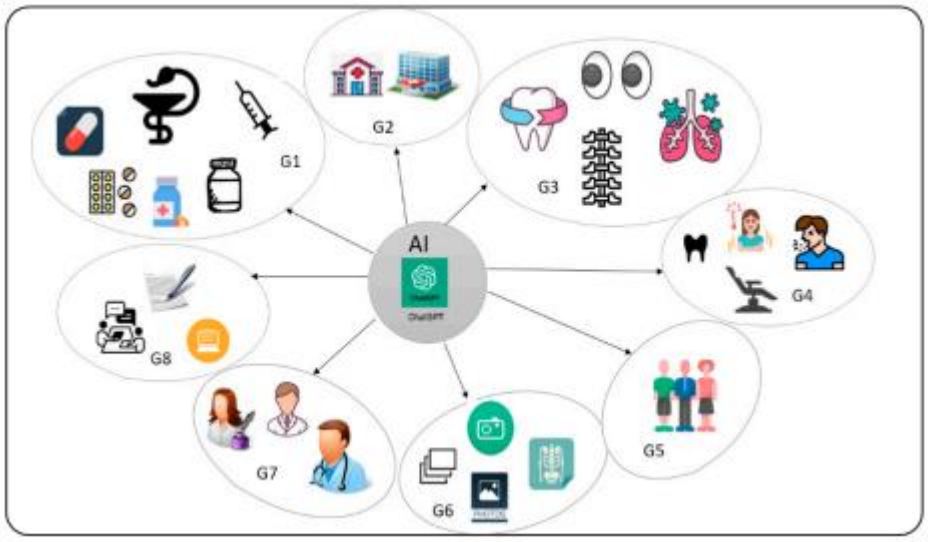


**Figure 2: Categorization Framework for AI Applications in Healthcare Studies**

(Source: Younis et al., 2024)

Also, ensuring that such integration will protect healthcare professional's place and respect other crucial factors related to the problem, including privacy and the possible exploitation of information models, are equally critical for healthcare providers. The authors thus conclude by supporting a balanced approach that integrates AI capabilities with human judgment to maximize healthcare outcomes.

## Evaluating AI in Hip Fracture Diagnosis and Postoperative Outcome Prediction

According to the authors (Lex et al., 2023), AI will be the source of promising applications in the detection of hip fractures and the outcome after surgery. This systematic review and meta-analysis assessed 39 studies that applied AI-based algorithms to diagnose hip fracture from radiographs and predict postoperative outcomes. The average diagnostic accuracy of the AI models equated to the expert clinicians; in fact, a sensitivity of 89.3%, specificity of 87.5%, and F1 score of 0.90 was achieved. The performance of all the models significantly varied in sensitivity and specificity. ML models exhibited a similar accuracy as traditional statistical approaches, namely, multivariable regression, for prediction of postoperative outcome; the average AUC obtained for ML-based predictions was 0.84 vs 0.79 using the latter. It is interesting that most predictions were associated

ISSN: 0975-3583, 0976-2833 VOL16, ISSUE 1, 2025

with mortality and hospital stay length; however, in these, ML-based performance is only minimally better compared with traditional models (Kuo et al., 2022). The results show that AI algorithms are capable of assisting clinicians but their superiority over existing methods is still inconclusive.

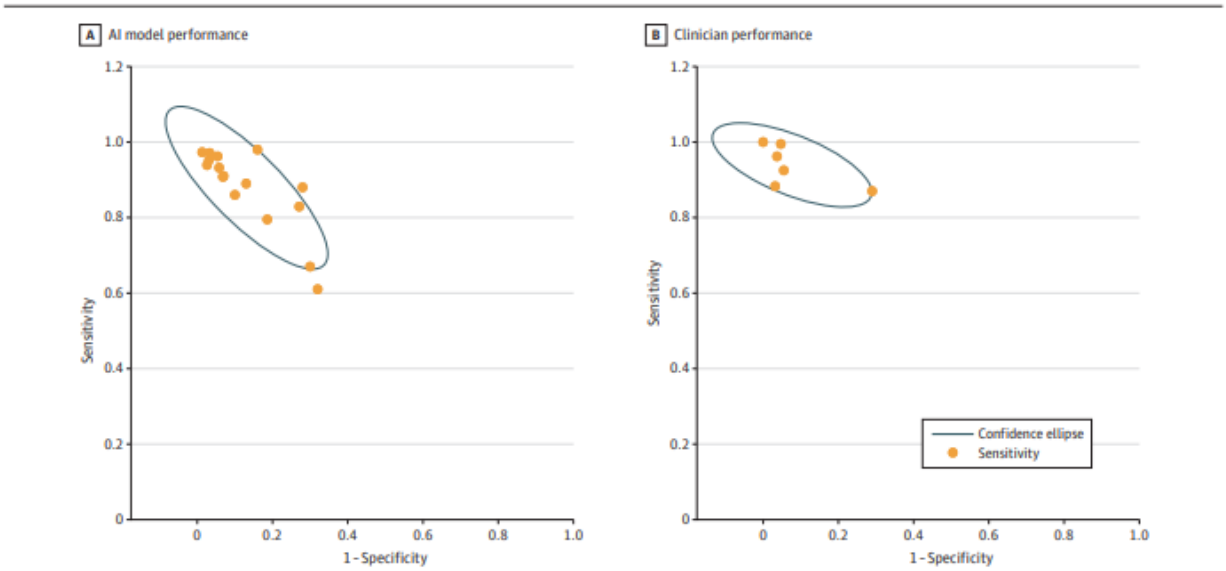


**Figure 3: Sensitivity and Specificity of AI and Clinicians in Diagnosing Hip Fractures**

(Source: Lex et al., 2023)

The study stresses the importance of external validation of AI algorithms on independent datasets and in clinical environments before wide-scale implementation. Data variability, ethical issues, and integration into care pathways pose challenges. However, AI may improve the accuracy of diagnosis and hasten clinical decision-making in resource-limited settings. Future research should be directed toward developing robust algorithms on diverse, high-quality datasets and assessing their impact on healthcare efficiency and patient outcomes.

## The Role and Impact of AI in Clinical Decision-Making

According to the authors (Jihed et al., 2022), Artificial intelligence (AI) greatly influences the enhancement of orthodontic treatment planning with increased diagnostic accuracy and enhanced decision-making during clinical procedures. This systematic review and meta-analysis includes 12

ISSN: 0975-3583, 0976-2833 VOL16, ISSUE 1, 2025

studies, of which five were taken into a quantitative synthesis to discuss the effectiveness of AI models in orthodontics. The outcome shows that the diagnostic performance of AI systems is quite impressive, where pooled sensitivity and specificity values are 96.5% and 96.2%, respectively, and an overall accuracy of 95.47%. AI techniques like ANNs, BNs, CNNs, and ML were evaluated. These models demonstrated promising results in the diagnosis of malocclusions, extraction planning, and orthognathic surgery needs. It was found that ANNs are the most commonly used technique and have excellent predictive ability for individualized treatment plans. It recognizes the limitations of AI integration, such as variability in clinical data and methodological heterogeneity across studies. Again, human oversight is essential in managing uncertainties and ethical considerations (Visaggi et al., 2022). The authors suggest that the use of AI models be further improved with broader validation, collaboration, and open-source code sharing that facilitates greater reliability and applicability. Overall, the study suggests that AI can enhance orthodontists' capabilities by providing secondary opinions, reducing variability in treatment planning, and improving patient outcomes. The integration of AI in orthodontics will save time, optimize resources, and improve the precision of treatment, thereby catering to the ever-increasing demand for personalized care. Future studies should focus on clinical trials to further validate the practical utility of AI in orthodontic settings.

## Methods

### Study Selection

This meta-analysis was performed with PRISMA guidelines to carry out the literature review in a systematic and transparent manner. All the relevant literature published between 2000 and 2024 were retrieved through PubMed, Scopus, Web of Science, and MEDLINE databases. Keywords used were "artificial intelligence," "surgical decision-making," "machine learning," and "deep learning." The inclusion criteria focused on studies that reported the use of AI in surgical decision-making, which should have measurable outcomes, such as diagnostic accuracy, risk prediction, or procedural optimization (Zhang et al., 2023). The exclusion criteria were studies with no quantitative data, non-English language, and reviews with no primary data. Two independent

ISSN: 0975-3583, 0976-2833 VOL16, ISSUE 1, 2025

reviewers screened titles and abstracts and resolved any discrepancies through consensus or third-party consultation.

## Data Extraction and Analysis

Data extraction was done in terms of characteristics of the studies such as the type, diagnosis, AI models used, clinical applications, and performances, such as sensitivity, specificity, and accuracy. The obtained data were presented in the table to analyze them systematically. Also due to high level of heterogeneity expected across the various studies, a random effects meta-analysis model was applied. The statistical measures entailed that of pooled sensitivity, specificity, DOR and AUC. Heterogeneity was evaluated with $I^2$ statistics and the publication bias using Deeks funnel plot asymmetry test. Subgroup analysis looked at how the results differed across the surgical specialties, the AI techniques used, as well as geographical areas.

## Risk of Bias and Quality Assessment

According to the QUADAS-2 instrument, the patient selection, index tests, reference standards, flow and timing of the included studies were critically reviewed. To eliminate such biases, an extensive assessment of the criteria is performed, and all of them can be divided into three groups: Low risk classified studies had similar and coherent approach with clear specification on participants selection, AI training data set and rigorous validation processes for the multiple models as indicated by Penny-Dimri and colleagues, 2022. Moderate and high risk studies, in contrast, could have fluctuations in sample sizes, unclear or inadequate documentation of AI training data sets and inadequate validation processes which reduced the validity of a study. Furthermore, the GRADE approach was used to evaluate the full body of evidence and categorise it into high, moderate, low or very low certainty. This classification helps give some understanding of the level of confidence should one use these results in clinical practices. By integrating these two tools, it was possible to gain insights into the quality of the evidence itself and the strength of the AI arguments, the domains where more research and standard development work is required before applying the decision support in the surgery practice.

ISSN: 0975-3583, 0976-2833 VOL16, ISSUE 1, 2025

# Results

## Diagnostic Accuracy of AI Models

A meta-analysis reviewing studies considering the accuracy assessment of artificial intelligence used in surgical decisions showed its ability to offer increased clinical accuracy from preoperative risk assessment up to intraoperative decision-making support level. Of the mentioned models, more frequently employed were ANNs and CNNs. Whether on a pathophysiological or even at a more refined level of surgical speciality, offering diagnostic performance throughout the wide spectrum of surgery.However, performance variability was observed because of differences in the quality of training data sets, model structures, and the approaches and methodologies (Wei et al., 2024). Some models did very well in certain circumstances, while other models were really poor when it came to the aspect of generalization. These variations show that there is a need to have parameters on data used by AI models as well as stringent validation methodologies to facilitate the necessary standardization that assures a reliable and consistent implementation of AI. Also, the studies revealed some of the tensions between the potential in AI use and the realities of implementing these solutions for heterogeneous clinical environments, as well as for ensuring interpretability to gain trust among clinicians. The results are therefore both stimulating and demanding with reference to the potential of AI for enhancing the surgical decision-making..

## Outcome Prediction and Risk Assessment

AI models have been promising predictors of postoperative outcomes, such as mortality rates, length of stay in the hospital, and risk of complications. Using advanced algorithms such as machine learning and ensemble methods, such as random forests, provides better predictive power than the traditional regression-based approaches. Personalized risk assessments can be obtained with these models, which aid in more informed clinical decision-making and resource allocation (Hashemi et al., 2024). Nevertheless, the limited external validation of such models raises questions about their applicability and accuracy for a broad range of patients and the clinical environments being inhabited. Inexperienced or variability in the training datasets, and lack of standardization or setting up of preconditions before deploying make these systems not very generalizable. The current limitations can only be addressed through Systematic testing of

ISSN: 0975-3583, 0976-2833 VOL16, ISSUE 1, 2025

developed AI models on differentiated and diverse datasets and the Attempts made to deploy these models to multiple healthcare settings. With improved version of the models and the validation of its effectiveness in other fields, AI becomes a usable solution for providing better outcomes in surgical procedures alongside enhancing the general care of the patient.

### Ethical and Practical Considerations

Concerns of ethical nature related to the use of AI in making decisions regarding surgery include issues such as the techniques used in the preparation of the data for training the artificial intelligence, this data will mostly originate from underrepresented populations thus causing poor outcomes. The collection of data that feeds such AI models, especially for training purposes also poses security risks on the sides of the patient's data. Another disadvantage of depending much on such systems is that patients can be a loss of clinical judgment and outcomes may be disastrous where unforeseen circumstances arise. The practical challenges associated with the modification of Clinical Information Systems in order to incorporate AI systems seemed to be complex as it requires infrastructure and training adjustments. This indicates that the application of AI is still complicated so far as signalling the official approval and acknowledges the ongoing premised dilemmas regarding its reliability and accountability. Next, one has concerns about the interpretability of the AI models, which may raise clinician mistrust and prevent them from using such AI systems (Kirubarajan et al., 2022). The solutions, however, are in model validation that insists on detailed and accurate models and formulation of ethical frameworks and stakeholder consensus to produce clearly defined regulatory standards. Consequently, there should be education for the clinician as well as development of how the design of AI should be made to promote safe, equitable, and effective surgical care.

## Discussion

As represented by this meta-analysis, (medical) AI generates significant value in transformative data analysis for surgical processes and decisions which include increased diagnostic performance, risk assessment, and planning. Studies have revealed that AI integrated platforms have had accuracy levels of a clinician and or an experienced professional and also ease in terms of time efficiency as well as expansiveness. Nevertheless, such development initiatives have been faced

ISSN: 0975-3583, 0976-2833 VOL16, ISSUE 1, 2025

by ethical or practical barriers when introducing AI. The variation in the study methods, participants involvements, approaches to validation, and sample size may affect the generalization of the outcomes (Habib et al., 2022). Some of the other issues include; privacy of data, inherent bias of the AI systems, and the ability of existing models to explain certain decisions. The results are consistent with prior studies that have posited that AI can augment rather than replace human discretion. Therefore, external confirmation, rules and guidelines, and staff education are essential elements. Healthcare professionals and other caregivers must work with AI developers to implement these recommendations and overcome the challenges to AI application, and ethical programming. Future research work will comprise using large datasets, explaining the algorithm, and performing randomized controlled trials to demonstrate the clinical applicability of AI.

## Future Directions

Surgical decision making with the help of AI must be based only on explainable models, and the main principles of such models are as follows – explainability and trust. Future AI is bound to be more diverse, large, and of high quality in a way that will make them more generalizable.

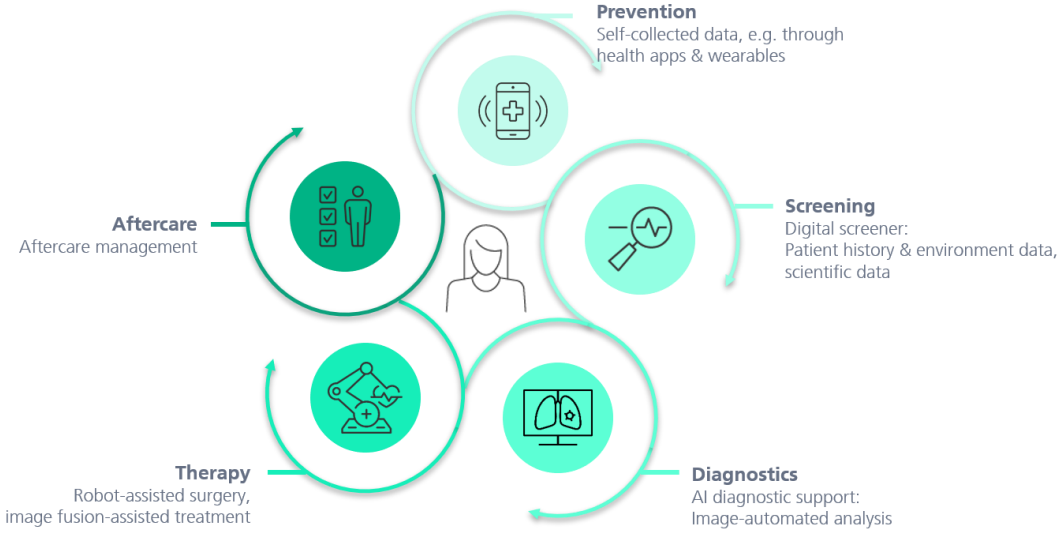


**Figure 4: AI in Healthcare**

(Source: www.iks.fraunhofer.de)

ISSN: 0975-3583, 0976-2833 VOL16, ISSUE 1, 2025

The integration of AI with other next generation technologies like augmented reality and robotic systems can significantly modify the intraoperative decision making. The same regulatory actions must be followed to set the right precaution measures in AI systems in clinical situations. Further, real-world problems will be solved using Engineering, Data Science, and Clinical acumen that would be developed to create new inventions on common platforms. To guarantee its easy integration, it should be ensured that the health care professionals are updated on the use and non-use of AI. The next steps in the AI research should be focused on a multicenter evaluation of AI usage on critical surgical parameters, effectiveness and cost-effectiveness of healthcare formulas.

## Conclusion

The study shows that artificial intelligence can help in changing the management process of surgery with better diagnosis, risk assessment and procedural planning. The meta-analysis offers empirical data to show that there is a validity in its capability to be equivalent to experienced clinicians; a fact that contains optimized approaches to enhancing patient care experience. However, significant challenges remain, including considerations of the ethical issues, data variation, and utilization of the new approaches in protocols. The four external factors essentially posed as barriers to achieving improvement objectives have been summarized as follows: External validation, the clarification of regulations, and stakeholder coordination will be critical in overcoming these barriers. Healthcare organizations' use of AI or the ability of a machine supplemented by a healthcare professional's specialization to enhance the process of delivering care during surgery is expected to expand across the horizon and reshape the future outlines of medical practice.

ISSN: 0975-3583, 0976-2833 VOL16, ISSUE 1, 2025

## Reference List

### Journals

Younis, H.A., Eisa, T.A.E., Nasser, M., Sahib, T.M., Noor, A.A., Alyasiri, O.M., Salisu, S., Hayder, I.M. and Younis, H.A., 2024. A systematic review and meta-analysis of artificial intelligence tools in medicine and healthcare: applications, considerations, limitations, motivation and challenges. Diagnostics, 14(1), p.109.

Lex, J.R., Di Michele, J., Koucheki, R., Pincus, D., Whyne, C. and Ravi, B., 2023. Artificial intelligence for hip fracture detection and outcome prediction: a systematic review and meta-analysis. JAMA network open, 6(3), pp.e233391-e233391.

Jihed, M.H., Dallel, I., Tobji, S. and ben Amor, A., 2022. The Impact of Artificial Intelligence on Contemporary Orthodontic Treatment Planning-A Systematic Review and Meta-Analysis. Sch J Dent Sci, 5, pp.70-87.

Henn, J., Buness, A., Schmid, M., Kalff, J.C. and Matthaei, H., 2021. Machine learning to guide clinical decision-making in abdominal surgery—a systematic literature review. Langenbeck's Archives of Surgery, pp.1-11.

Kuo, R.Y., Harrison, C., Curran, T.A., Jones, B., Freethy, A., Cussons, D., Stewart, M., Collins, G.S. and Furniss, D., 2022. Artificial intelligence in fracture detection: a systematic review and meta-analysis. Radiology, 304(1), pp.50-62.

Visaggi, P., Barberio, B., Gregori, D., Azzolina, D., Martinato, M., Hassan, C., Sharma, P., Savarino, E. and de Bortoli, N., 2022. Systematic review with meta-analysis: artificial intelligence in the diagnosis of oesophageal diseases. Alimentary pharmacology & therapeutics, 55(5), pp.528-540.

Zhang, B., Zhu, F., Li, P. and Zhu, J., 2023. Artificial intelligence-assisted endoscopic ultrasound in the diagnosis of gastrointestinal stromal tumors: A meta-analysis. Surgical Endoscopy, 37(3), pp.1649-1657.

Penny-Dimri, J.C., Bergmeir, C., Perry, L., Hayes, L., Bellomo, R. and Smith, J.A., 2022. Machine learning to predict adverse outcomes after cardiac surgery: A systematic review and meta-analysis. Journal of Cardiac Surgery, 37(11), pp.3838-3845.

ISSN: 0975-3583, 0976-2833 VOL16, ISSUE 1, 2025

Habib, A.R., Kajbafzadeh, M., Hasan, Z., Wong, E., Gunasekera, H., Perry, C., Sacks, R., Kumar, A. and Singh, N., 2022. Artificial intelligence to classify ear disease from otoscopy: a systematic review and meta-analysis. Clinical Otolaryngology, 47(3), pp.401-413.

Wei, Q., Yao, Z., Cui, Y., Wei, B., Jin, Z. and Xu, X., 2024. Evaluation of ChatGPT-generated medical responses: a systematic review and meta-analysis. Journal of Biomedical Informatics, p.104620.

Hashemi, H., Doroodgar, F., Niazi, S., Khabazkhoob, M. and Heidari, Z., 2024. Comparison of different corneal imaging modalities using artificial intelligence for diagnosis of keratoconus: a systematic review and meta-analysis. Graefe's Archive for Clinical and Experimental Ophthalmology, 262(4), pp.1017-1039.

Kirubarajan, A., Young, D., Khan, S., Crasto, N., Sobel, M. and Sussman, D., 2022. Artificial intelligence and surgical education: a systematic scoping review of interventions. Journal of Surgical Education, 79(2), pp.500-515.