Enhanced Decision Making in Arthroplasty with Retrieval-Augmented Generation Enabled Large Language Models

PLABAN NATH CHOWDHURY [1]

[1]Orthopedics

INTRODUCTION:

Clinical decision-making in arthroplasty is a multifaceted process that demands consideration of diverse patient-specific variables, the continual advancement of implant technologies, and a growing volume of clinical literature. Traditional decision-support systems, often limited by static data inputs and rigid algorithms, are increasingly inadequate in managing this complexity. As a result, there is a pressing need for more dynamic, intelligent tools that can synthesize information in real time and provide contextualized guidance to orthopaedic surgeons.

METHODS:

This study investigates the integration of Retrieval-Augmented Generation (RAG) with large language models (LLMs) to enhance clinical decision-making in arthroplasty. RAG-LLMs operate by retrieving relevant information from up-to-date medical literature and combining it with deep natural language understanding to generate tailored, evidence-based recommendations. We developed a prototype system designed to support three core aspects of arthroplasty: implant selection, surgical planning, and patient-specific risk stratification. The methodology includes constructing clinical scenarios, querying RAG-LLMs, and evaluating the quality, relevance, and accuracy of the generated recommendations against expert benchmarks and standard decision-support tools.

RESULTS:

Initial implementation and testing of the RAG-LLM framework demonstrated significant improvements in both decision accuracy and workflow efficiency. The system effectively contextualized clinical inputs—such as comorbidities, anatomical considerations, and patient preferences—while incorporating the latest evidence from peer-reviewed literature. Surgeons reported greater confidence in the recommendations provided, and preliminary evaluations showed a higher degree of alignment with expert consensus compared to traditional tools.

DISCUSSION AND CONCLUSION:

The use of RAG-LLMs represents a major advancement in clinical decision support. Unlike conventional systems, which are often constrained by pre-defined rules or outdated databases, RAG-LLMs dynamically retrieve and interpret current medical knowledge. This enables real-time adaptability to evolving evidence and individualized patient contexts. Key challenges remain, including the need for robust validation, integration with electronic health records, and user interface optimization, but the initial findings highlight the potential for transformative impact on surgical decision-making.

RAG-enabled large language models offer a promising path forward in personalizing and modernizing decision-making processes in arthroplasty. By bridging the gap between static decision aids and the dynamic nature of clinical practice, this approach has the potential to improve outcomes, reduce variability in care, and empower surgeons with actionable, evidence-informed insights. Future work will focus on scaling the technology, validating it in diverse clinical settings, and exploring its application across other orthopaedic subspecialties.