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The Role Of Computer-Assisted Navigation In Total Knee Arthroplasty Outcomes: A Systematic Literature Review

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ABSTRACT

The increasing use of Total Knee Arthroplasty (TKA) to treat severe osteoarthritis demands high surgical precision to ensure optimal alignment, reduce complications, and improve implant longevity. Computer-Assisted Navigation (CAN) has emerged as a technological solution to enhance accuracy in TKA; however, its long-term clinical effectiveness remains debated. This study aims to systematically assess whether CAN significantly improves TKA outcomes compared to conventional methods. Using PRISMA and Cochrane Collaboration guidelines, a systematic literature review was conducted involving 19 eligible peer-reviewed studies published between 2014 and 2024, retrieved from Scopus, PubMed, and Crossref. Data were analyzed using a narrative synthesis approach. Findings indicate that CAN improves radiological alignment and reduces certain complications, including soft tissue damage and inflammatory responses. However, evidence regarding its impact on functional outcomes, patient satisfaction, and revision rates remains inconclusive. Although some studies reported better postoperative range of motion and marginal increases in patient satisfaction, others found no significant difference. These mixed results highlight the need for further longitudinal and randomized studies. The study underscores CAN's potential in improving surgical accuracy, while urging continued research to validate its broader clinical and economic value.

Keywords: *Total knee arthroplasty, computer-assisted navigation, outcomes, alignment, complications.*

INTRODUCTION

Total Knee Arthroplasty (TKA) is one of the most successful and commonly performed orthopedic procedures aimed at relieving pain and restoring function in patients with severe knee osteoarthritis. Studies indicate that the success rate of TKA is notably high, with patient satisfaction rates reported between 85.2% and 92.0% post-surgery (Bansal et al., 2021). Furthermore, TKA is associated with low revision rates, typically below 5% at ten years, underscoring its reliability as a treatment option (Liddle et al., 2015).

Despite advancements in implant designs and surgical techniques, achieving optimal alignment and function remains a challenge, directly affecting patient outcomes and implant longevity. Inaccurate component positioning and alignment can lead to complications such as joint instability, wear, and the need for revision surgery. Deviations greater than 3° in the coronal plane are associated with increased revision rates and poorer functional scores (Alcelik et al., 2017). Study has shown that malalignment can result in disproportionate tension on ligaments, leading to complications such as pain and stiffness, which may ultimately necessitate revision (Husein & Mohammed, 2022). Therefore, optimal alignment correlating with improved functional scores and patient overall satisfaction (Mugnai et al., 2016).

The increasing demand for TKA, especially among aging populations, has heightened the importance of improving surgical accuracy and patient outcomes. In recent years, Computer-Assisted Navigation (CAN) has emerged as a potential solution to address alignment inaccuracies in TKA. This method provides real-time intraoperative feedback, allowing surgeons to make immediate adjustments to component alignment, which is critical for achieving optimal outcomes (De Steiger et al., 2015). Studies indicate that CAN improves the accuracy of component placement, correlating with better postoperative knee function and reduced rates of malalignment (Hernández-Vaquero et al., 2010; Jiang et al., 2017). While several studies have explored the benefits of CAN in TKA, there remains debate over whether the technology consistently translates into superior clinical outcomes compared to conventional techniques.

Despite the growing body of literature, current evidence remains inconclusive regarding the long-term effectiveness of CAN in improving functional outcomes and reducing revision rates. Some studies suggest that CAN improves alignment accuracy, yet others find no significant differences in patient-reported outcomes or long-term implant survival. Furthermore, there is a lack of comprehensive reviews that systematically assess both the

quantitative and qualitative impacts of CAN on various aspects of TKA outcomes, including functional recovery, alignment precision, and patient satisfaction.

This systematic literature review aims to evaluate the role of Computer-Assisted Navigation in enhancing total knee arthroplasty outcomes. The review will critically assess existing studies to determine whether CAN offers tangible benefits over traditional methods, focusing on key factors such as post-operative impact, functional recovery, complication rates, and overall patient satisfaction. By synthesizing the available evidence, this research seeks to clarify the clinical significance of CAN in TKA and identify potential areas for future investigation.

Despite the increasing prevalence of total knee arthroplasty (TKA) and the growing integration of computer-assisted navigation (CAN) technologies, there remains considerable debate regarding the long-term clinical efficacy of CAN. While CAN is designed to improve surgical precision, alignment accuracy, and reduce complications, its actual impact on functional outcomes and revision rates remains inconclusive. This uncertainty hinders evidence-based adoption of CAN in standard clinical protocols and necessitates a deeper, more systematic evaluation of its clinical benefits.

The global rise in knee osteoarthritis, particularly among aging populations, has significantly increased the demand for total knee arthroplasty procedures. As surgical volumes grow, achieving optimal outcomes becomes critical to minimize the socioeconomic burden of postoperative complications and revision surgeries. In this context, CAN offers the promise of enhanced precision in component placement, which is believed to correlate with better alignment and long-term implant survival. Given the association between malalignment and poor outcomes, validating CAN's effectiveness is of urgent importance for orthopedic practice.

Moreover, current adoption rates of CAN vary widely due to cost, training demands, and mixed reports in the literature. Without clear and consistent evidence supporting its superiority over conventional techniques, healthcare providers face challenges in decision-making regarding its integration. Thus, a systematic review that critically synthesizes existing research is necessary to inform clinical guidelines, optimize patient care, and justify the use of CAN in routine practice.

Several studies have examined the role of CAN in enhancing surgical accuracy during TKA. For example, Deep et al. (2017) and Hernández-Vaquero et al. (2010) demonstrated improved implant alignment with CAN, leading to better mechanical axis restoration. Similarly, Jiang et al. (2017) reported comparable outcomes in alignment accuracy using both pinless and pinned CAN systems. These findings collectively suggest that CAN consistently delivers more precise component placement compared to conventional techniques.

However, studies evaluating functional outcomes and patient satisfaction reveal mixed results. Goh et al. (2018) and Lee et al. (2019) reported that despite better alignment, there was no significant improvement in long-term patient-reported outcomes or implant survivability. Khuangsirikul et al. (2016) also found similar satisfaction levels between conventional and navigation-assisted TKA, even after 10 years. Such findings question whether precision alone is sufficient to impact overall surgical success.

Some research highlights reduced complication rates and faster recovery with CAN. Kamalapathy et al. (2021) found lower acute complications in over 54,000 navigation-assisted TKA cases, while Ochs et al. (2016) observed better range of motion postoperatively. Additionally, studies by Razak et al. (2014) and Siu et al. (2019) suggest physiological benefits such as milder contractures and lower thrombotic markers, indicating CAN's broader impact beyond alignment.

Although numerous studies have addressed specific outcomes of CAN in TKA, there is a lack of comprehensive synthesis evaluating its collective impact across critical dimensions—alignment precision, functional recovery, complication reduction, and patient satisfaction. Most existing works either focus on radiological outcomes or short-term metrics, without integrating evidence to assess long-term clinical significance. This study addresses that gap through a systematic literature review spanning a decade of research.

This study offers a novel, integrative perspective by systematically analyzing 19 recent studies to evaluate the holistic impact of CAN in total knee arthroplasty. Unlike prior reviews, it consolidates diverse outcome measures including alignment accuracy, functional recovery, revision rates, complication profiles, and patient satisfaction. The findings aim to clarify CAN's practical value and support evidence-based decisions regarding its adoption in orthopedic surgery.

The objective of this research is to evaluate the role of computer-assisted navigation in total knee arthroplasty by systematically analyzing its effects on alignment accuracy, functional outcomes, complication rates, and patient satisfaction compared to conventional techniques, with the aim of determining its clinical value and informing future surgical practice.

The findings of this study will benefit orthopedic surgeons, hospital administrators, and policymakers by providing a comprehensive evidence base on the effectiveness of CAN in TKA. It will inform surgical decision-making, guide investment in surgical technology, and contribute to optimizing patient care. Additionally, the review may serve as a foundation for future research and the development of advanced navigational systems.

METHOD

The research employed a systematic literature review method, a rigorous and structured approach designed to identify, evaluate, and synthesize all relevant research studies on a specific topic. This methodology followed the PRISMA-P (Preferred Reporting Items for Systematic Reviews and Meta-Analysis Protocols) guidelines and adhered to the standards recommended by the Cochrane Collaboration. The focus of the review was to assess the clinical role of computer-assisted navigation (CAN) in total knee arthroplasty (TKA) procedures. The research question was framed using the PICO framework, which defined the Population (patients undergoing TKA), Intervention (use of CAN), Comparison (conventional TKA methods), and Outcomes (alignment accuracy, functional recovery, complication reduction, and implant survivability).

The systematic search was conducted in September 2024, utilizing reputable academic databases such as Scopus, PubMed, and Crossref. The researchers used a well-defined set of keywords—"computer-assisted navigation" and "total knee arthroplasty"—along with Boolean operators and wildcard characters to capture variations of the search terms. The inclusion criteria were restricted to peer-reviewed articles published in English between 2014 and 2024, with full-text availability and open access. From an initial pool of 388 documents, a multi-stage filtering process involving title, abstract, and full-text review resulted in the final selection of 19 eligible studies.

To reduce bias and ensure accuracy, at least two researchers independently reviewed each article. The selected studies were assessed based on relevance, methodological quality, and consistency with the review objective. Data extraction included critical information such as title, author, publication year, study aims, sample characteristics, research design, and key findings. The analysis was conducted using a narrative synthesis approach, which allowed the researchers to summarize the outcomes, identify recurring patterns, and derive comprehensive insights across the reviewed literature. This method enabled a holistic understanding of the effectiveness and implications of CAN in improving outcomes for TKA procedures.

A systematic review is a rigorous research approach that can be employed to address these inquiries. Systematic reviews can amalgamate findings from multiple-research to offer more robust evidence regarding the effectiveness of different types of interventions on improving the utilization of health facilities for childbirth. The inclusion and exclusion criteria in this study can be seen in table 1.

Table 1. Inclusion and Exclusion Criteria

Inclusion	Exclusion
Article that discussed the role of Computer-Assisted Navigation in enhancing total knee arthroplasty outcomes	Articles that are not related to the role of Computer-Assisted Navigation in enhancing total knee arthroplasty outcomes
Research article	Non research article
English documents	Non-English documents
Published year 2014-2024	Published outside 2014-2024
Available in full text	Not available full text
Open access	Non-open access
Research conducted in many countries	
Quantitative, qualitative, experimental research methods	Systematic review method, literature review, non-research

Source: Data processed

RESULTS AND DISCUSSION

Based on search results using preset keywords and inclusion criteria, 388 potential papers were first obtained from three literature databases: Scopus (n=101), PubMed (n=87), and Crossref (n=200). Following the title screening process, 308 articles with relevant context were identified. After removing duplicate papers (N = 112), those not published between 2014 and 2024 (N = 91) and non-open access articles (N = 48). A subsequent screening of abstracts resulted in the review of 57 papers, with 38 abstracts failing to meet the set criteria. A subsequent full-text inspection was performed to determine eligibility, resulting in the inclusion of 19 papers in the study.

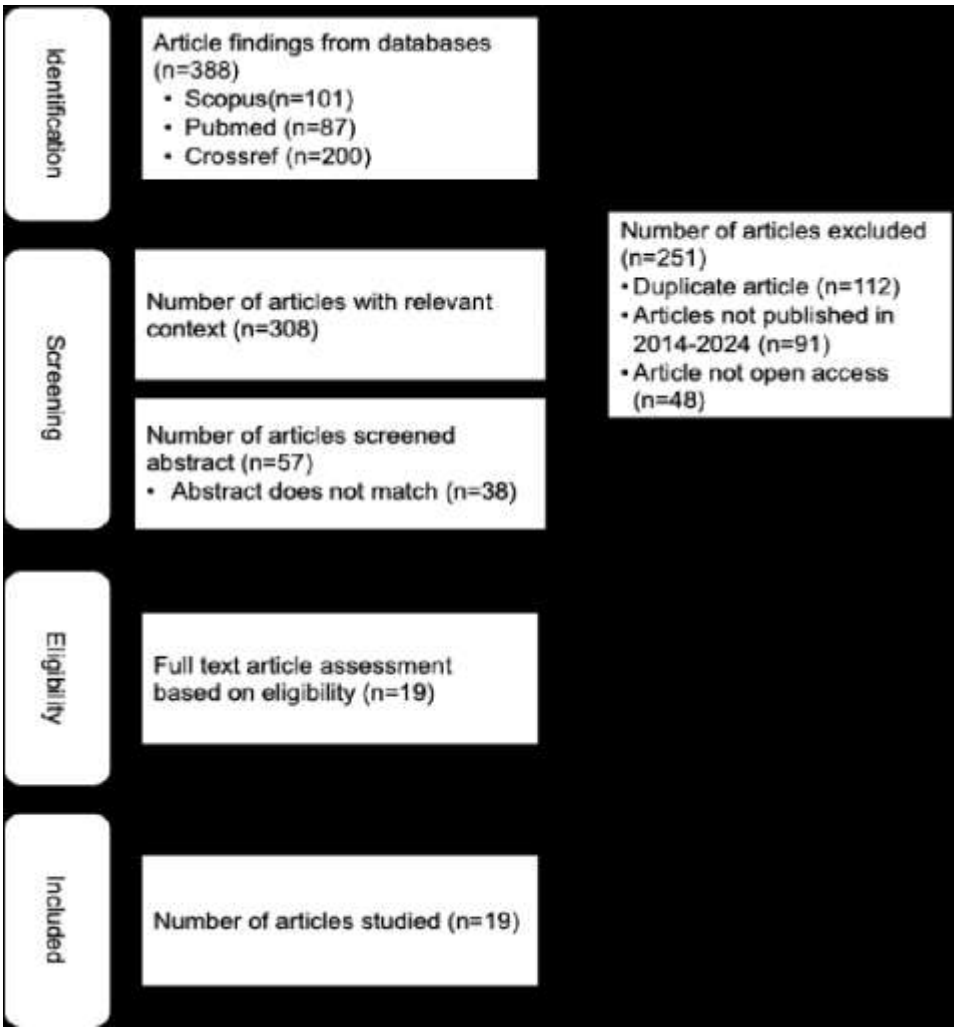

Figure 1. Article Extraction Process Flowchart

Bendich et al. (2021) conducted a retrospective analysis of 1,307,411 elective total knee arthroplasties (TKA) performed in the United States from 2010 to 2018. The study aimed to update the utilization trends of computer-assisted navigation (CAN) and robotic assistance (RA) in TKA and compare 90-day readmission rates. The results showed that 92.8% of TKAs were conventional, but the use of technology-assisted procedures increased annually, with RA-TKA having the lowest 90-day readmission rates.

Cerny et al. (2022) presented a case study involving a 60-year-old female patient with complex deformities and retained hardware. The patient underwent computer-navigated TKA, which resulted in optimal alignment without postoperative complications or hardware loosening. Deep et al. (2017) reviewed existing literature and meta-analyses to assess the benefits of computer-assisted navigation in both knee and hip arthroplasty. They concluded that the technology improves surgical accuracy, alignment, functional outcomes, and reduces revision rates.

Goh et al. (2018) conducted a prospective study comparing accelerometer-based navigation (ABN), computer-assisted surgery (CAS), and conventional methods (CON) in 152 TKA cases. ABN showed improved alignment accuracy, but there were no significant differences in functional outcomes among the groups. Hsu et al. (2019) studied 60 patients undergoing staged bilateral TKAs, with one knee receiving CAS and the other conventional TKA. Although CAS demonstrated better alignment, both procedures yielded similar clinical outcomes after an eight-year follow-up.

Jiang et al. (2017) conducted a retrospective case-control study comparing 200 TKA cases—100 using pinless navigation and 100 using pinned CAS. The pinless group had shorter surgery times, but both groups achieved similar clinical results after two years. Kamalapathy et al. (2021) analyzed data from 54,114 navigation-assisted TKAs and 539,073 conventional TKAs, finding that navigation-assisted procedures reduced both major and minor complications without increasing hospital utilization.

Kamara et al. (2017) evaluated 839 patients with 3,136 pin sites used during navigation-assisted arthroplasty. Only three cases of pin site infection were reported, indicating a low complication rate. Khakha et al. (2015) conducted a randomized controlled trial involving 92 patients to compare mid-term outcomes of TKAs

performed by consultants versus trainees using CAS. The study found no significant differences in Knee Society Scores (KSS), suggesting comparable outcomes. Khuangsirikul et al. (2016) evaluated 10-year patient satisfaction and outcomes in 70 patients receiving computer-assisted minimally invasive TKA and 74 receiving conventional techniques. No significant differences were found in satisfaction or WOMAC scores between the two groups.

Kuo et al. (2018) compared inflammation markers (IL-6, IL-10, TNF-α, TGF-β1) in 97 patients undergoing TKA via computer navigation versus conventional methods. The navigation group showed smaller increases in these markers at 24 and 72 hours postoperatively. McClelland et al. (2017) studied gait and knee biomechanics in 81 TKA patients (39 conventional, 42 navigated) and 40 healthy controls. Results indicated that navigated TKAs more closely replicated normal knee biomechanics.

Ochs et al. (2016) analyzed clinical and radiological outcomes in 31 patients who underwent computer-navigated modular rotating-hinge knee arthroplasty. Postoperative results showed improved knee range of motion and reduced varus-valgus deviation. Razak et al. (2014) compared flexion contracture severity between 235 conventional and 235 navigated TKA patients. Navigated TKA resulted in significantly milder contractures (1° vs. 6°) with no outliers in the navigated group.

Roberts et al. (2015) assessed 9,054 primary TKAs to determine if computer navigation improved functional outcomes and implant survivability. The study found no significant differences between navigated and conventional approaches. Song et al. (2020) conducted a retrospective analysis of 472 patients using computer-assisted navigation to assess coronal alignment after TKA based on preoperative varus deformity. Group 2, with greater deformity, had a 2.01 times higher occurrence of outliers than Group 1.

Talsania and Balachandar (2023) compared surgical times in 60 patients undergoing conventional versus navigation-assisted robotic TKA. Their retrospective randomized study found no significant differences in operative duration. Zhu et al. (2016) performed a 9-year prospective follow-up study of 108 patients to compare outcomes between minimally invasive computer-assisted TKA (MICA-TKA) and conventional TKA. Both groups demonstrated comparable functional and radiographic results. Siu et al. (2019) analyzed 174 TKA patients to evaluate plasma d-dimer and fibrinogen levels between navigation-assisted and conventional methods. Navigation-assisted TKA showed lower plasma d-dimer levels and milder postoperative increases.

Post-Operative Impact of Computer-Assisted Navigation in Total Knee Arthroplasty

The post-operative impact of computer-assisted navigation (CAN) in total knee arthroplasty (TKA) has potential benefits and limitations. The integration of CAN into TKA procedures aims to enhance surgical precision, improve functional outcomes, and reduce complications.

One of the primary advantages of CAN in TKA is its ability to improve the accuracy of component positioning, which is crucial for achieving optimal limb alignment and joint function. Studies have shown that computer navigation significantly enhances the precision of component placement compared to conventional techniques. For instance, Khakha et al. demonstrated that accurate component orientation and restoration of mechanical limb alignment are associated with better long-term outcomes in TKA (Khakha et al., 2015). Similarly, Jiang et al. reported that the use of CAN leads to improved precision in individual component placement, which is critical for the success of the procedure (Jiang et al., 2017). Furthermore, Ochs et al. noted that both primary and revision surgeries benefit from CAN, as evidenced by significant improvements in the Hospital for Special Surgery Knee Score and range of motion post-operatively (Ochs et al., 2016). Furthermore, studies have shown that CAN can lead to lower levels of inflammatory markers post-operatively, suggesting a more favorable healing environment (Siu et al., 2019).

In addition to functional outcomes, the impact of CAN on radiological alignment has been well-documented. Study found that CAN is more effective than conventional methods in achieving the desired coronal alignment, which is essential for minimizing wear and prolonging implant longevity (Song et al., 2020). This is corroborated by Lee et al., who indicated that inaccurate positioning of components is linked to risks such as abnormal wear and premature implant failure (Lee et al., 2019). Moreover, the use of CAN has been associated with reduced rates of flexion contracture post-operatively, as reported by Razak et al., suggesting that the technique may facilitate better soft tissue balance (Razak et al., 2014). Malyavko et al. highlighted that the introduction of computer navigation in TKA has been associated with reduced early revision rates and medical complications when compared to non-navigated procedures (Malyavko et al., 2022).

Despite these advantages, some studies have raised concerns regarding the mid- to long-term outcomes of CAN compared to conventional TKA. Study reported that while CAN reduces mechanical axis outliers, it does not lead to significant improvements in quality of life or functional outcomes compared to conventional TKA (Goh et al., 2018). This highlights the need for further research to determine the long-term benefits of CAN in TKA.

The potential for increased surgical duration and costs associated with CAN is another consideration. Talsania noted that while navigation-assisted TKA aims to improve precision, concerns regarding prolonged surgery times persist (Talsania & Balachandar, 2023). However, some studies suggest that the benefits of improved alignment and reduced complication rates may outweigh these drawbacks. For instance, Bendich et al. observed that technology-assisted arthroplasty, including CAN, has been associated with lower complication rates compared to conventional approaches (Bendich et al., 2021).

In conclusion, the post-operative impact of computer-assisted navigation in total knee arthroplasty presents a complex picture. While evidence supports its benefits in enhancing alignment accuracy and improving functional outcomes, questions remain regarding its long-term advantages and implications for surgical efficiency. Continued investigation into the comparative effectiveness of CAN versus conventional techniques is essential to fully understand its role in optimizing patient outcomes in TKA.

Functional Recovery Impact of Computer-Assisted Navigation in Total Knee Arthroplasty

The computer-assisted navigation (CAN) on total knee arthroplasty (TKA) enhanced the precision of surgical procedures, which may lead to improved post-operative outcomes, including functional recovery. One of the key benefits of CAN in TKA is its ability to improve the accuracy of component alignment, which is crucial for optimal knee function post-operatively. Deep et al. (2017) reported that the use of CAN leads to better alignment of implants, which correlates with enhanced knee function and longevity of the prosthesis, particularly in younger patients. Similarly, Lin et al. found that patients undergoing CAN-assisted TKA experienced significant improvements in the American Knee Association scores, with preoperative scores increasing from 57 ± 13 to 90 ± 6 postoperatively (Lin et al., 2020).

Furthermore, Ochs et al. demonstrated that CAN not only improves alignment but also significantly enhances the range of motion (ROM) post-operatively. Their study reported an increase in average ROM from $90.9° \pm 15.1°$ preoperatively to $114.4° \pm 15.8°$ postoperatively, indicating that patients benefit from improved mobility following surgery (Ochs et al., 2016). This is critical, as greater ROM is often associated with higher levels of patient satisfaction and functional recovery.

However, the evidence is not entirely uniform, as some studies have indicated that while CAN improves alignment, it does not necessarily lead to significant differences in functional outcomes when compared to conventional techniques. For instance, Goh et al. found that although CAN reduced mechanical axis outliers, this did not translate into improved functional outcomes or quality of life compared to conventional TKA (Goh et al., 2018). This raises questions about the extent to which alignment precision impacts functional recovery, suggesting that other factors may also play a role in post-operative outcomes.

Moreover, the learning curve associated with implementing CAN can initially prolong surgical times, which may impact early recovery. Talsania noted that while CAN aims to improve precision, the increased operating time during initial surgeries can be a concern (Talsania & Balachandar, 2023). However, as surgeons become more familiar with the technology, the benefits of improved alignment and reduced complication rates may outweigh these initial drawbacks, leading to better long-term outcomes.

In conclusion, the use of computer-assisted navigation in total knee arthroplasty appears to positively influence functional recovery, primarily through improved alignment and range of motion. While some studies suggest that the benefits of CAN may not always translate into significant differences in functional outcomes compared to conventional methods, the overall trend indicates that CAN can enhance recovery in many patients. Continued research is necessary to further elucidate the long-term benefits and potential limitations of this technology in TKA.

Complication Rates of Computer-Assisted Navigation in Total Knee Arthroplasty

The complication rates associated with computer-assisted navigation (CAN) in total knee arthroplasty (TKA) comparing it to conventional techniques and highlighting specific types of complications that may arise. Kamalapathy et al. conducted a large-scale study involving over 54,000 patients and found no increased risk of acute complications or hospital utilization when using navigation-assisted techniques compared to conventional methods (Kamalapathy et al., 2021). This finding is corroborated by Bendich et al., who reported that both CAN and robotic assistance for TKA demonstrated increased precision in component positioning without a corresponding increase in complication rates (Bendich et al., 2021). These studies indicate that CAN may not only enhance surgical accuracy but also maintain safety standards comparable to traditional approaches.

However, some studies have highlighted specific complications associated with CAN. For example, pin-related complications, such as pin site infections and pain, have been documented in the context of navigation-assisted surgeries. A study by Kamara et al. noted that pin site complications were a concern, although the overall incidence was relatively low (Kamara et al., 2017). Additionally, Razak et al. reported that while CAN resulted in less severe flexion contracture, it did not eliminate the risk of complications entirely (Razak et al., 2014). These findings suggest that while CAN can mitigate some risks, it introduces new challenges that must be managed.

Moreover, Lee et al. conducted a study that concluded there were no significant differences in mid- to long-term outcomes between CAN and conventional TKA, implying that while CAN may improve alignment, it does not necessarily reduce the overall complication rates (Lee et al., 2019). This raises important questions about the clinical significance of the improvements in alignment achieved through navigation, as the expected reduction in complications may not always materialize.

In terms of specific complications, Kuo et al. found that the use of CAN was associated with lower levels of inflammatory markers post-operatively, which could suggest a potential reduction in complications related to

inflammation (Kuo et al., 2018). Conversely, Hsu et al. highlighted that while CAN improved alignment, it did not significantly reduce the rates of complications such as venous thromboembolism when compared to conventional techniques (Hsu et al., 2019). This indicates that while CAN may enhance certain aspects of surgical outcomes, it does not universally lower all complication rates.

In conclusion, the evidence suggests that computer-assisted navigation in total knee arthroplasty can lead to improved alignment and potentially lower rates of certain complications. However, it is also associated with specific risks, particularly related to pin placement and soft tissue management. The overall impact on complication rates compared to conventional techniques remains a nuanced topic, with some studies indicating no significant differences in long-term outcomes. Continued research is essential to fully understand the implications of CAN in TKA and to optimize its application in clinical practice.

Patient Satisfaction of Computer-Assisted Navigation in Total Knee Arthroplasty

The patient satisfaction associated with computer-assisted navigation (CAN) in total knee arthroplasty (TKA) is an important aspect of evaluating the overall effectiveness of this surgical approach. Studies have shown that CAN significantly reduces the incidence of malalignment, which is associated with poor functional outcomes and increased revision rates (Jiang et al., 2017; McClelland et al., 2017; Roberts et al., 2015). Furthermore, the use of CAN has been linked to improved patient satisfaction due to better postoperative outcomes, including reduced pain and enhanced mobility (Khuangsirikul et al., 2016).

One of the primary factors influencing patient satisfaction post-TKA is the functional outcome, which is often measured using various scoring systems. Study reported significant improvements in the Knee Society Score (KSS) following navigation-assisted TKA, with scores increasing from 58.8 ± 13.7 preoperatively to 96.0 ± 2.8 postoperatively (Zhu et al., 2016). Such improvements in functional scores are likely to correlate with higher levels of patient satisfaction, as patients experience better mobility and reduced pain.

Moreover, Ochs et al. reported that the use of CAN in TKA resulted in an increase in average range of motion (ROM) from $90.9° \pm 15.1°$ preoperatively to $114.4° \pm 15.8°$ postoperatively (Ochs et al., 2016). Enhanced ROM is a critical component of patient satisfaction, as it directly affects the ability to perform daily activities and engage in recreational pursuits. Patients who regain a functional range of motion are more likely to report satisfaction with their surgical outcomes.

Research indicates that patients undergoing CAN-assisted TKA report higher satisfaction levels compared to those who receive conventional surgery. For instance, a study comparing patient satisfaction over a ten-year period found that those who underwent CAN-assisted procedures experienced better functional outcomes and reported higher satisfaction rates (Khuangsirikul et al., 2016). Additionally, the precision afforded by CAN minimizes the need for extensive soft tissue release, which can lead to postoperative complications and dissatisfaction (Eachempati et al., 2022). This is particularly important in patients with complex deformities or previous surgeries, where traditional methods may not yield optimal results (Cerny et al., 2022; Khakha et al., 2015).

Moreover, the advantages of CAN extend beyond immediate surgical outcomes. Long-term studies have demonstrated that patients who receive computer-assisted TKA tend to have lower rates of complications and revisions, contributing to sustained satisfaction over time (Lee et al., 2019; Talsania & Balachandar, 2023). The ability of CAN to enhance the accuracy of component placement not only improves the mechanical alignment but also aligns with the patients' anatomical variations, further enhancing their functional recovery and overall satisfaction (McClelland et al., 2017; Song et al., 2020).

In conclusion, the evidence supports that computer-assisted navigation in total knee arthroplasty significantly enhances patient satisfaction through improved surgical precision, reduced complications, and better functional outcomes. As the technology continues to evolve, its integration into routine practice is likely to further optimize patient care in orthopedic surgery.

CONCLUSION

Computer-Assisted Navigation (CAN) in total knee arthroplasty (TKA) offers notable advantages in enhancing surgical precision, particularly in achieving optimal component alignment, which can reduce complications and potentially improve implant longevity. While CAN has consistently demonstrated improvements in radiological alignment over conventional methods, its effects on functional outcomes, patient satisfaction, and revision rates remain inconclusive. Some studies report marginal gains, whereas others find no significant differences compared to traditional techniques. Moreover, the higher costs and longer surgical times associated with CAN raise questions about its cost-effectiveness, although these may be offset by reductions in postoperative complications. Overall, CAN presents as a promising technological advancement in orthopedic surgery, yet its long-term clinical superiority is not definitively established. Future researchers are encouraged to conduct longitudinal, multicenter, randomized controlled trials that not only assess alignment and complication

rates, but also rigorously evaluate patient-reported outcomes, cost-efficiency, and quality of life over extended follow-up periods to better determine the comprehensive value of CAN in TKA procedures.

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