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Meta-Analysis

Is robotic-arm-assisted total knee arthroplasty less traumatic? A meta-analysis

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ABSTRACT

Objective was to identify inflammatory responses that predict postoperative total knee arthroplasty (TKA) outcome. The robotic TKA has resulted decreased tissue trauma. This review aims to determine the level 1 evidence of inflammatory responses following robotic and conventional jig-based TKA as inflammatory markers provide an objective method for assessing the invasiveness of the surgery. A systematic search according to the guidelines for preferred reporting items for systematic reviews and meta-analysis (PRISMA) of the existing literature was performed on the electronic databases PubMed, Scopus and Ovid until the 1st of June 2023. Inclusion criteria were randomized controlled trials (RCTs), written in the English language and published in the last ten years, focusing on studies that evaluated the influence of inflammatory markers (O) on robotic TKA (I) and conventional jig based (C) TKA in end-stage knee osteoarthritis patients (P) were included in the study. The inverse variance method analyzed continuous outcomes as standard mean difference (SMD), random effect model and 95% confidence intervals (CI). In total, among the 557 articles, four studies were included. One hundred sixty-five patients were included, and various inflammatory markers and patient-reported outcome measures were analysed. This meta-analysis showed that R-TKA showed a decreased inflammatory response compared to C-TKA [interleukin (IL)-6 (Std. mean diff. {IV, random, 95 CI}=-1.22 {-1.78, -0.66}, C reactive protein (CRP) (-1.07 {-2.01, -0.13}, erythrocyte sedimentation rate (ESR)=-0.65 {-1.17,-0.12} with a significant $p<0.05$] with no significant changes in terms of patient-reported outcome measures Western Ontario and McMaster universities osteoarthritis index (WOMAC)=-0.25 {-0.59,0.09}, knee society score (KSS)=0.18 {-0.34, 0.70}, and functional outcome range of motion (ROM)=-0.22 {-0.62, 0.17} with a $p>0.05$. Robotic-arm-assisted TKA has decreased early postoperative inflammatory response. High powered studies assessing the predictive value of metabolic and inflammatory factors pre and post-surgery and the already evidenced risk factors with follow-up greater than one year after TKA are warranted.

Keywords: Inflammatory markers, Pain, Robotic total knee arthroplasty, Conventional total knee arthroplasty

INTRODUCTION

There is a projected growth of TKA increases exponentially when compared to 2019 data.[1] With the advent of numerous robotic system today there is high chance of increased number of robotic TKA in the future. The robotic assisted TKA has led to improved early function, significantly less estimated blood loss and lower inflammation levels, particularly IL-6, in the early

postoperative phase.[2] There is a rising evidences in regards to inflammatory markers pattern post robotic TKA. It has been observed in the literature that there is decreased trend in the inflammatory markers among the robotic TKA patients when compared to conventional TKA. There are recent literature attributing the raised inflammatory state as one of the reason for pain.[3] The decreased inflammatory due to reduced soft tissue injury might outweigh the disadvantages such as prolonged surgery and cost.[4]

In the era of emerging technology and artificial intelligence, if there a ability to decrease in inflammation will result in optimum outcome. The aim of this systematic review and metanalysis was to critically appraise the trend of the inflammatory markers in robotic TKA. If there is a decrease in the inflammation might turn out to be a potential advantage of the robotic system There by it might increase the insight of the robotic knee assistance in the TKA.

METHODS

Inclusion criteria

The study followed PRISMA guideline. In this study, RCTs were incorporated to compare inflammatory markers in patients with primary knee osteoarthritis undergoing robotic-assisted TKA with those undergoing conventional TKA.

The excluded studies are those that focused on patients with rheumatoid arthritis and studies on other surgical interventions assisted by robots that did not involve fully robotic TKA (handheld device). Studies that did not make a direct comparison between robotic TKA and traditional TKA were not considered.

We only incorporated studies that examined relevant outcomes for this analysis. The main outcomes were the markers of inflammation such as IL-6, CRP and ESR. The secondary outcomes were the WOMAC score, KSS and the ROM in those studies which studied the primary outcome

Database search methods

We performed a database search of PubMed (January 2012 to June 2023), Ovid (January 2012 to June 2023) and Scopus (January 2012 to June 2023).

The search was conducted as per the PRISMA guidelines (Figure 1).

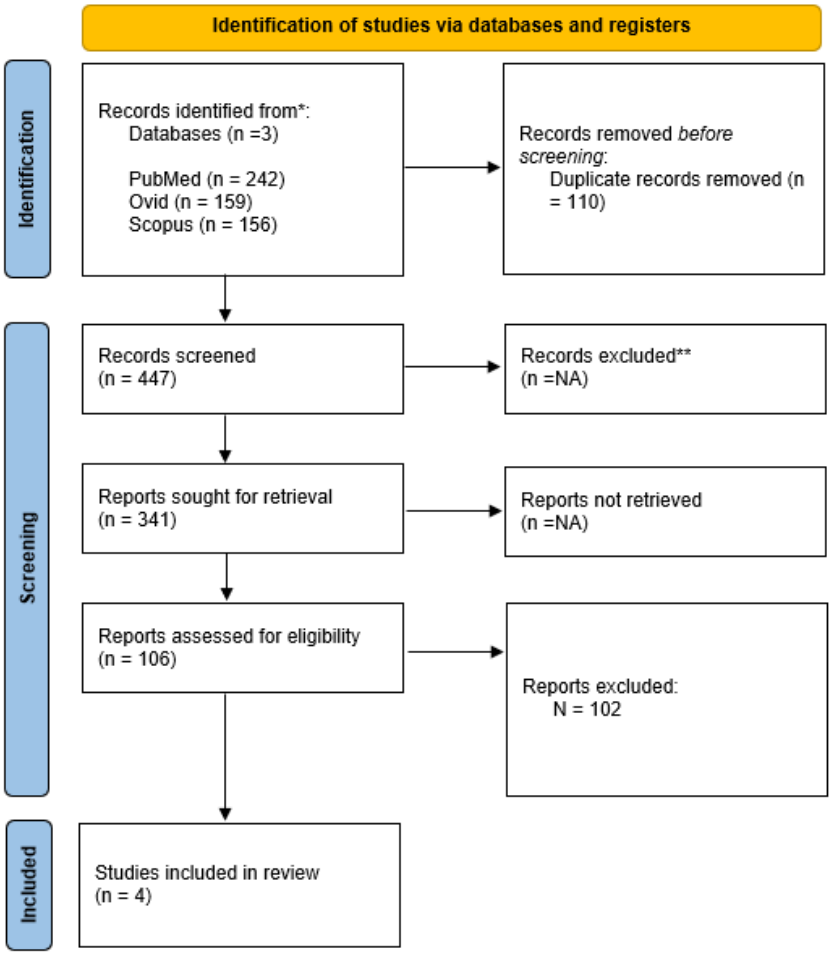

Figure 1: The PRISMA flow chart of study selection and inclusion.

Selection of studies and data extraction

After eliminating duplicate entries, two reviewers conducted a separate evaluation of the titles and abstracts. Articles that were deemed possibly eligible by either of the reviewers were included in the full-text review. The two reviewers also assessed the complete texts to verify the suitability of the studies. The study data that was included was extracted in an independent manner. They settled any disagreements in any of the processes through discussion. If additional bias in the screening process was present, a senior orthopedic consultant was called and rectified the matter. The extracted data from each study comprised the identification of the first author, publication year, study setting, study population, intervention details and its comparator, funding source, and findings for the relevant outcomes.

Assessment of risk of bias and quality of the evidence

Two independent reviewers assessed each study's likelihood of bias using the Cochrane collaboration's technique for randomized trials. Furthermore, risk of bias (RoB) 2.0 tools was used to assess the risk of bias for each outcome in the included studies. Interpretation and implications of the pooled estimates and their 95% CIs were based on the minimal important differences (MIDs) derived from the literature and approved by experienced knee surgeons. The MIDs for KSS score was 6 points (Figure 2).[5]

Statistics

The studies were conducted using the RevMan Web program. The random-effects models were utilized to do the meta-analyses, considering the presence of heterogeneity between studies. We employed the generic inverse variance method to examine continuous outcomes, specifically measuring the mean difference (MD) and calculating the corresponding 95% CIs. In this review, we specifically chose immediate follow-up time-point from each trial to assess all functional outcomes. We conducted a visual examination of the forest plots from the combined analysis and examined the I2 statistics and chi-square test to identify any indications of heterogeneity (I2>50%).

Ethics, registration, data sharing, funding, and disclosures

Our study did not need ethics approval. All approaches followed appropriate standards and legislation. An unsupported study. There are no conflicting interests or other interests that could influence this paper's outcomes. Three of the five authors supervising the clinical setting of the study are orthopaedic surgeons with little expertise in robotic knee surgery, ensuring no potential conflict of interest. The authors declare no financial assistance from firms that produce or distribute the medications, equipment, or materials in this research.

RESULTS

Search and characteristics of studies

Out of the 557 citations obtained from electronic databases, any duplicate entries were eliminated. We evaluated 106 complete texts and incorporated 4 suitable RCTs in the ultimate analysis of this study.[6-9] Details of screening and selection process is presented in Figure 1. Characteristics of included studies are presented (Table 1).

All 4 included studies are parallel-group RCTs published during 2010-2023. 4 studies were conducted in China and UK. A total of 170 patients was studied in the group. The Yuanha robotic system (China) and Mako (Stryker, Portage, MI, USA) used in these studies. All studies employed neutral mechanical alignment concept, except Kayani et al.[6] who focused on functional alignment. Three studies received funding from governmental and non-profit organizations. Off which one study had a potential financial conflict of interest with the robot manufacturer.

Risk of bias in included studies

The assessment of the study-level risk of bias is displayed in Figure 2. All studies were prone to a significant risk of performance bias. The comprehensive assessment of potential bias for each study outcome is displayed in Figure 2. We displayed the risk of bias at the outcome level for each study using a forest plot.

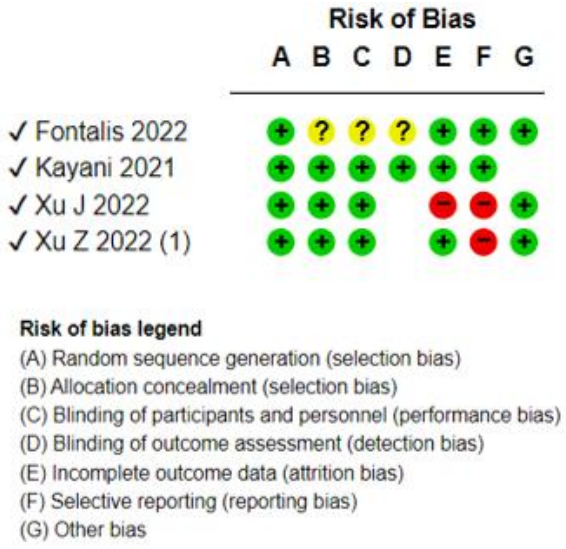

Figure 2: Study-level risk of bias summary.

IL 6, CRP and ESR

Two studies reported the IL6 values in 60 participants. As shown in Figure 3, the IL 6 was on average 1.22 points lower (CI=-1.78 to 0.66, moderate certainty) in the RATKA than in the COTKA group (I2=0%, p=0.69). Two studies reported the CRP values in 63 participants. As shown in Figure 3, the CRP was on average 1.07 points

lower (CI=-2.01 to -0.13, moderate certainty) in the RATKA than in the COTKA group (I2=67%, p=0.08). Two studies reported the ESR values in 63 participants. As shown in Figure 3, the ESR was on average 0.65 points lower (CI=-1.17 to -0.12, moderate certainty) in the RATKA than in the COTKA group (I2=6%, p=0.30).

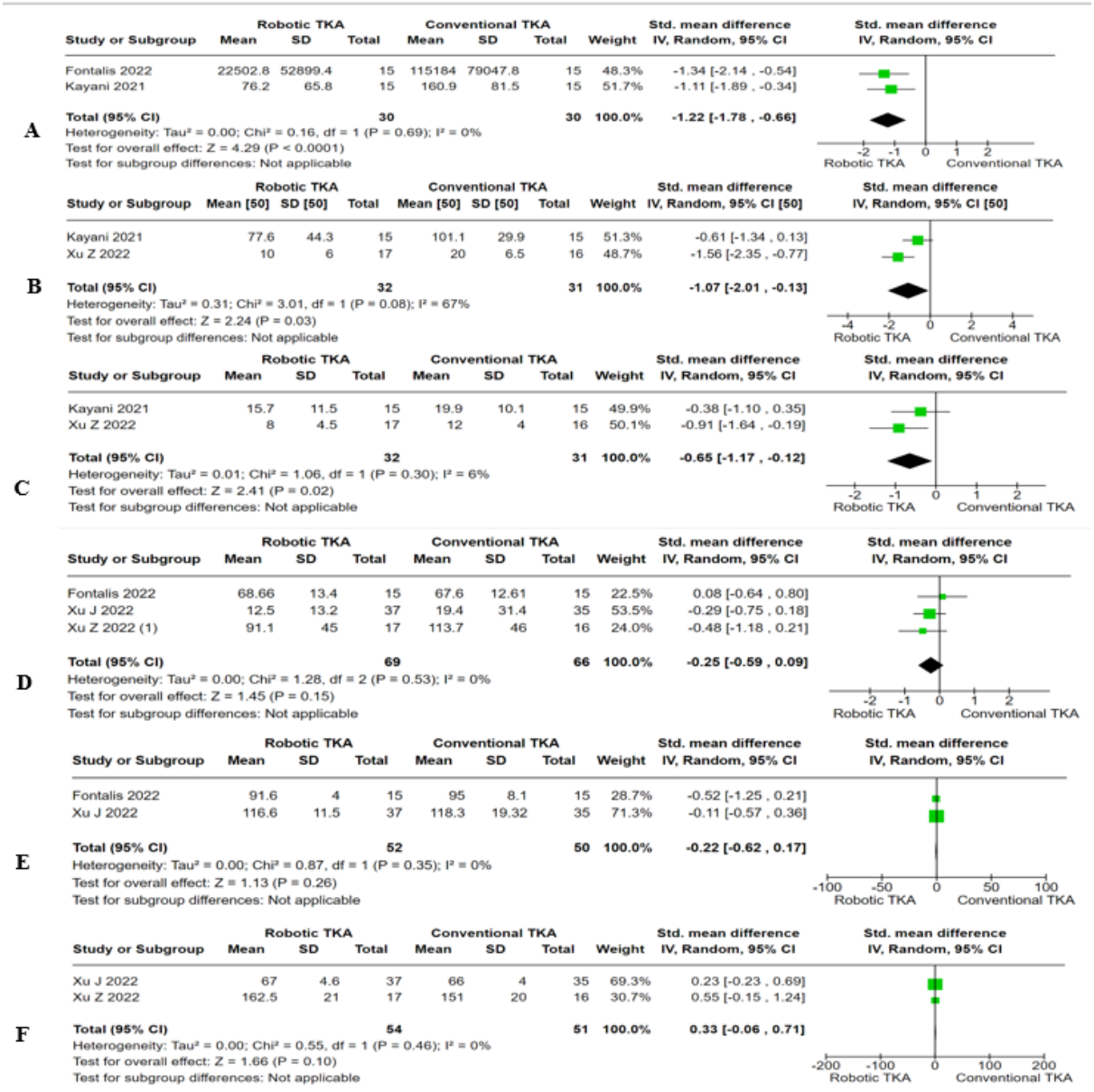

Figure 3: Forest plots of the A-IL 6, B-CRP, C-ESR, D-WOMAC, E-ROM, and F-KSS.

Functional outcome

The functional outcome was measured using WOMAC, ROM and KSS. Three studies reported the WOMAC scores in 140 participants. As shown in Figure 3, the WOMAC score was on average 0.25 points higher (CI=0.59 to 0.09, moderate certainty) in the RATKA than in the COTKA group (I2=0%, p=0.53). 2 studies reported the ROM in 107 participants. As shown in Figure 3, the ROM score was on average 0.22 points higher (CI=0.62 to 0.17, moderate certainty) in the RATKA than in the COTKA group (I2=0%, p=0.35). 2 studies reported the KSS scores in 110 participants. As shown in Figure 3, the WOMAC score was on average 0.33 points higher (CI=0.06 to 0.71, moderate certainty) in the RATKA than in the COTKA group (I2=0%, p=0.46).

DISCUSSION

From this systematic review and metanalysis, robotic TKA probably results in decreased inflammatory markers compared to conventional TKA. The evidence also suggests decreased pain in the early postoperative period among patients who underwent robotic TKA. The literature describes serum inflammatory markers as directly correlated with acute postoperative pain.[10] Most of the studies have demonstrated no clinical superiority of robotic TKA versus Conventional TKA, but in this study,

we found some evidence supporting against the pre-existing literature.[5]

The IL6 is one of the reliable markers of inflammation. After surgery, IL-6 levels peak 24 hours later and drop to normal after two weeks.[11] In major surgery, cytokine activation is a well-documented event. IL-6 can be produced during surgery by a variety of stimuli, and there is a correlation between the amount of this protein and the degree of tissue damage, inflammation, and oedema.[12] Pro-inflammatory cytokines cause preoperative peripheral and central sensitization by sensitizing peripheral nerve terminals.[13] The IL-6 is an indirect indicator of pain, and its correlation with the pain level are well established in the literature.[10]

In addition to the CRP serving as a specific marker for PJI, is a more reliable marker for pain. The change in CRP is primarily related to surgical trauma.[14] The duration in which the CRP returns to normal levels post TKA is prolonged as long as 8 weeks and depends upon the patient-related factors and defers the Anglo-Saxon trend which was described previously in literature.[15] The degree of serum elevation is related to bone and medullary injury rather than soft tissue.[16] The ESR has numerous causes of elevation, even idiopathic is a cause of elevated ESR.[17] The ESR sensitivity and specificity is low when compared to IL 6 and CRP. In most of the studies in this analysis shows decreased pain among the robotic knee arthroplasty patients in the immediate postoperative period when compared to the conventional group of patients. The main causes which may attribute to the decreased inflammatory markers are avoiding intramedullary opening of the canal for sig placement, ability to balance the soft-tissue with less soft-tissue release, decrease metal debris (burr reduces trauma when compared to saw) and multiple pin placement for the attachment of the sig in conventional TKA might cause increased insult to periarticular tissue.[18]

The limitation of the systematic review and meta-analysis is the small sample size in each study. Long-term prospective studies are needed to look for any changes in the functional outcome among the patients.

Table 1: Study characteristics.

Author and year	Study setting	Population	Robotic system	Alignment	Surgical technique	Outcome	Conflict of interest	Fund received
Kayani et al, 2021[6]	United Kingdom	N=30 patients R-TKA-15 C-TKA-15	Mako system, Stryker	Mechanical alignment	Measured resection and soft tissue balancing	Postop serum inflammatory markers on 6 hrs, day 1, 2, 7 and 28 MASTI score	None	No
Xu et al, 2022[8]	China	N=33 patients R-TKA-17 C-TKA-16	YUANHUA (Yuanha robotic system)	Mechanical alignment	Measured Resection and soft tissue balancing	Knee function was evaluated by the knee ROM, KSS, and WOMAC, serum levels of inflammatory markers before operation and day 1, 3, and 30	None	Yes
Fontalis et al, 2022[7]	United Kingdom	N=30 patients R-TKA-15 C-TKA-15	Stryker	R-TKA-functional alignment C-TKA-mechanical alignment	R-TKA - functional alignment C-TKA-measured resection and soft tissue balancing	Local inflammatory (Drain) markers (IL6) on 6 hrs, and day1. VAS score at POD 1, 2, 3 and 7. PROMS: WOMAC, KOOS, OKS, EQ-5D, SF 12 VAS	None	Yes
Xu et al, 2022[9]	China	N=77 patients R-TKA-37 C-TKA-35	Yuanha robotic system	Mechanical alignment	Measured resection and soft tissue balancing	Postop serum inflammatory markers on day 1, 3 and 30 knee function evaluation: WOMAC, KSS and ROM	None	Yes

CONCLUSION

The recent literature suggests a decreased inflammatory response when compared to conventional TKA, which will obviously influence postoperative pain, rehabilitation and recovery. This advantage can be considered as an exceptional advantage in enhanced recovery after knee replacement surgery. Long-term prospective studies are needed to establish this fact. The decreased inflammatory response, in turn, reduces pain, which is a boon to the patients undergoing robotic TKA. In addition, accurate implant positioning, ligament balance, and limb alignment lead to increased prosthesis survivorship.

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Conflict of interest: None declared
Ethical approval: Not required

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