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Review article

Are personalized alignment strategies achievable in revision total knee arthroplasty? A scoping review of the current literature

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ABSTRACT

Personalized alignment strategies, including kinematic alignment (KA), restricted kinematic alignment (rKA), and functional alignment (FA), are emerging as alternatives to mechanical alignment in total knee arthroplasty (TKA). These approaches aim to restore patient-specific limb alignment and joint-line orientation, potentially improving functional outcomes. Although their use is well established in primary TKA, evidence supporting their application in revision total knee arthroplasty (rTKA) remains limited. The complexity of revision surgery, together (combined) with implant constraints and altered anatomy, has historically hindered the adoption of personalized alignment. This scoping review aims to evaluate the current evidence regarding the feasibility, accuracy, and clinical outcomes of personalized alignment strategies in rTKA and unicompartmental knee arthroplasty (UKA) toTKA conversion. A scoping review was conducted using PubMed, Scopus and Web of Science to identify English-language clinical studies published between January 2010 and December 2024. Eligible studies reported the use of KA, rKA, or FA in revision TKA or UKA conversion. Case reports, case series, cohort studies, and technical notes were included, whereas computational studies, cadaveric reports, and investigations limited to primary TKA were excluded. Two reviewers independently assessed study eligibility and extracted data regarding the alignment strategy, radiographic restoration, surgical workflow, range of motion (ROM), patient-reported outcome measures (PROMs), and complications. Ten clinical studies met the inclusion criteria. Across the included literature, personalized alignment demonstrated technical feasibility in revision settings and was associated with improved joint-line restoration, limb alignment closer to constitutional values, and good postoperative ROM. Patient-reported outcome measures (PROMs), when reported, showed a trend toward improvement. No major complications directly attributable to personalized alignment techniques were described. Robotic-assisted FA, described in four studies, suggested the precision of bone resections and soft-tissue balancing. However, the evidence base remains limited by small sample sizes, heterogeneous methodologies, and short-term follow-up. Personalized alignment strategies appear feasible and clinically beneficial in selected revision TKA cases. Early data suggest that KA, rKA, and FA may improve alignment accuracy and functional outcomes without increasing complications. Nevertheless, heterogeneity in study design and limited long-term evidence constrain broader adoption. Future research should prioritize standardized protocols, comparative trials, and long-term survivorship to define the role of personalized alignment in rTKA.

1. Introduction

Revision total knee arthroplasty (rTKA) is an increasingly common procedure and represents the gold standard treatment for failed or symptomatic primary TKA, as well as for failed unicompartmental knee arthroplasty (UKA).[1,2] Despite substantial improvements in implant design, surgical techniques, and postoperative protocols, clinical outcomes following revision surgery remain inferior to those of primary TKA. National joint registries report survivorship rates significantly lower than primary procedures, and patient dissatisfaction after rTKA exceeds that of primary TKA, with many patients continuing to experience pain, instability, or functional limitations.[3,4] Current challenges in

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revision surgery are closely tied to the difficulty in restoring native knee biomechanics, particularly anatomical joint-line orientation, limb alignment, and soft-tissue balance. These factors are central to post-operative function, yet are often altered following implant removal, bone loss, and the use of stemmed components.[5,6]

Over the last two decades, there has been growing interest in alignment strategies that move beyond traditional mechanical alignment (MA). Functional alignment (FA) and Kinematic Alignment (KA) with its variants as restricted Kinematic Alignment (rKA) or Inverse Kinematic Alignment (iKA) attempt to individualize bone resection and implant positioning to reproduce the patient's constitutional anatomy and joint-line orientation more closely. KA aims to restore the pre-arthritic joint line, rKA introduces safe boundaries to prevent excessive deviations, and FA incorporates robotic real-time soft-tissue tension and dynamic alignment assessment to guide component placement.[7,8] These concepts have gained significant traction in primary TKA, with studies reporting improved patient-reported outcome measures (PROMs), more natural knee kinematics, and reduced need for soft-tissue releases.[9,10] Parallel to the evolution of alignment strategies, technological innovations have transformed orthopedic practice. According to the latest national arthroplasty reports, more than half of all TKAs performed in technologically advanced healthcare systems are now "technology-assisted," including navigation, patient-specific instrumentation, and robotic platforms.[11] These technologies provide improved intraoperative accuracy, real-time feedback on alignment and ligament tension, and enhanced reproducibility factors that are particularly relevant in the revision setting, where anatomy is frequently distorted and reproducibility is more difficult to achieve.[12,13]

Among these technological advancements, robotic systems have become increasingly integrated into personalized alignment strategies. Robotic assistance facilitates precise bone resection, reliable intraoperative assessment of the soft-tissue envelope, and consistent application of FA principles. Early clinical reports suggest that robotics may mitigate some of the technical limitations that previously restricted the use of KA or FA in revision surgery, such as the need for stems constraining (that constrain) implant positioning to the diaphyseal axis.[14,15] As a result, robotic-enabled FA is emerging as a promising tool to individualize revision procedures and optimize patient outcomes. Despite these advancements, significant knowledge gaps remain in the application of personalized alignment to revision surgery. Current evidence is limited to small case series, retrospective cohorts, and technical notes. Standardized protocols are lacking, long-term survivorship is unknown, and comparative data are scarce. Furthermore, the impact of personalized alignment on PROMs, implant durability, and postoperative complications in revision settings has not been comprehensively evaluated.

The aim of this scoping review is to summarize the current clinical evidence regarding the use of personalized alignment strategies (KA, rKA, and FA) in revision TKA and UKA to TKA conversion. Specifically, we focused on three main objectives: (I) describing the alignment philosophies applied in revision procedures; (II) evaluating clinical and radiographic outcomes associated with personalized alignment; and (III) assessing the role of robotic assistance in supporting FA and alignment personalization in revision surgery. This review is presented in accordance with the PRISMA-ScR reporting guidelines.

2. Materials and methods

2.1. Search strategy

For this scoping review, relevant studies were searched in the Medline (PubMed), Scopus and Web of Science databases using the following key terms: "kinematic alignment", "restricted kinematic alignment", "functional alignment", "revision total knee arthroplasty", "UKA conversion", "personalized alignment"*, and* "robotic knee surgery". Articles published between January 2010 and December 2024 were considered. The last search was performed on December 15, 2024. This review was intentionally designed as a scoping review to comprehensively map the breadth of available evidence on emerging personalized alignment strategies in revision knee arthroplasty, a field characterized by heterogeneous study designs, evolving surgical techniques and limited high-level comparative data. The search methodology followed the PRISMA-ScR guidelines to ensure transparency and reproducibility. In addition, the methodological framework proposed by Arksey and O'Malley and further refined by Levac et al. was adopted to guide the identification, selection and synthesis of relevant studies.[16,17] The literature search was conducted independently by two authors, who screened titles, abstracts, and full-text articles. Disagreements were resolved through discussion with a senior reviewer.

2.2. Selection criteria

This review includes clinical research related to the application of personalized alignment strategies, specifically kinematic alignment (KA), restricted kinematic alignment (rKA), and functional alignment (FA), in revision total knee arthroplasty (rTKA) and UKA to TKA conversion. Eligible studies comprised case reports, case series, retrospective analyses, cohort studies, and technical descriptions. The inclusion of a wide range of study designs is consistent with the exploratory nature of a scoping review, which aims to capture the full extent of available evidence rather than restrict analysis to high-level comparative studies. Only articles published in English were included. Studies were excluded if they focused solely on primary TKA without revision or conversion components, if they lacked clinical outcome data, or did not specifically apply KA, rKA, or FA principles.

2.3. Data extraction

All relevant information was extracted into a predesigned data matrix. Extracted variables included: first author and year of publication, study design, alignment strategy used (KA, rKA, FA), implant type (primary vs revision, stemmed vs unstemmed), presence of robotic assistance, intraoperative workflow, radiographic alignment outcomes, range of motion (ROM), patient-reported outcome measures (PROMs), and complication rates. Data extraction was performed independently by two reviewers (SR and MC). In cases of disagreement, a senior author was consulted to reach consensus (PFI). Consistent with scoping review methodology, no formal risk of bias assessment was performed, as the objective was to provide an overview of the existing literature rather than to generate pooled estimates of effect.

2.4. Statistical analysis

Descriptive statistical analysis was performed for all extracted data. Continuous variables were summarized using mean values, with measures of variability expressed as standard deviation (SD) or range (minimum–maximum), when available. Categorical variables were reported as absolute counts and frequency distributions. Due to the heterogeneity of methodologies and limited sample sizes, no meta-analysis was performed. This approach aligns with the scoping review design, which does not typically aim to quantitatively synthesize data but rather to identify patterns, knowledge gaps, and areas for future research. When included studies reported comparative analyses, corresponding *P* values were recorded and reported for completeness.

3. Results

Initially, a total of 268 potentially relevant articles were retrieved from the database search. After removal of duplicates, 224 records were screened based on title and abstract, leaving 23 full-text articles for eligibility assessment. Following full evaluation, 10 studies met the inclusion criteria and were incorporated into the final analysis (Fig. 1). Among the included papers, five studies investigated revision TKA using

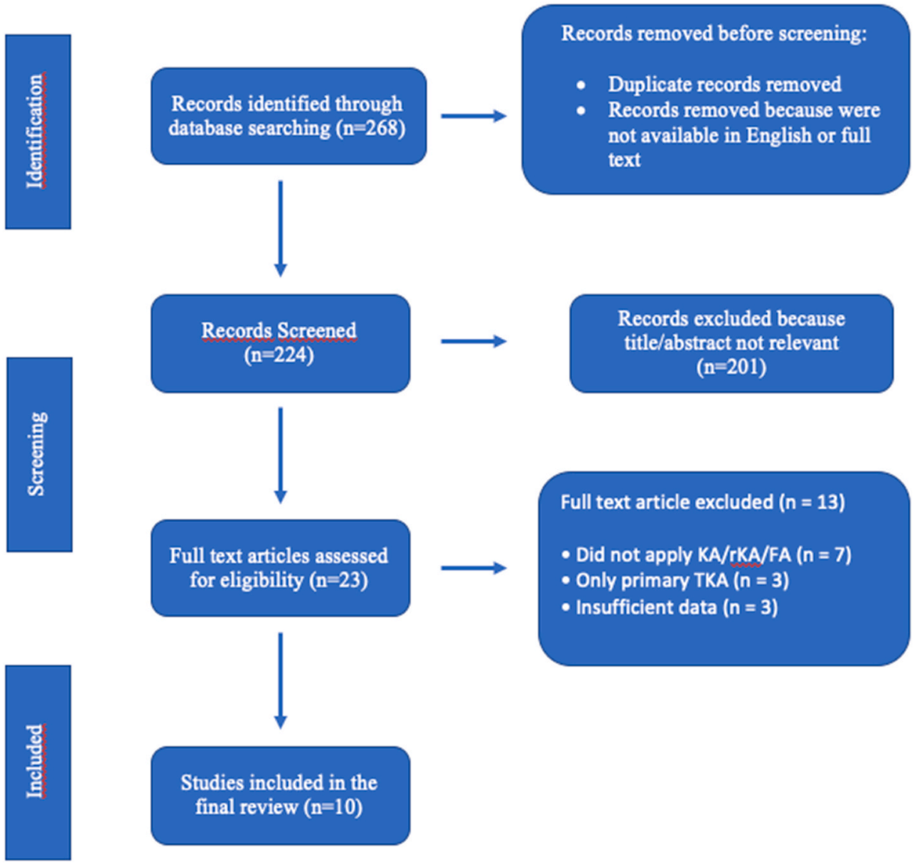

Fig. 1. Flowchart. Identification of studies via databases.

kinematic alignment (KA), one applied restricted kinematic alignment (rKA) and four utilized robotic assistance to perform functional alignment (FA). Four of these reported unicompartmental knee arthroplasty (UKA) conversions performed according to personalized alignment principles.

Shelton et al. reported outcomes of converting medial UKA to KA-TKA, demonstrating that restoring the patient's constitutional alignment resulted in functional outcomes comparable to primary KA-TKA, without increasing operative complexity.[18]

Similarly, Toliopoulos et al. compared anatomic versus mechanical alignment in UKA revision and showed that anatomical joint-line preservation provided improved functional scores.[19]

Sappey-Mariner et al. presented a case series of seven patients revised from mechanically aligned TKA to KA-TKA, reporting restoration of constitutional limb alignment and improvements in PROMs, supporting the feasibility of applying KA principles in revision contexts.[20]

Kostretzis et al. described the use of restricted kinematic alignment (rKA) in revision TKA, applying safe alignment boundaries to accommodate bone loss and stemmed implants. Their cohort demonstrated reliable reconstruction of joint-line obliquity and satisfactory early outcomes.[21]

Carlson et al. detailed a technical application of KA during revision of a well-fixed mechanically aligned TKA, highlighting the importance of accurately restoring joint-line orientation despite implant constraints.[22]

With the increasing adoption of robotic technology in knee arthroplasty, several authors explored its role in FA-guided procedures. Mancino et al. reported a robotic-assisted series of UKA to TKA conversions performed using functional alignment principles, showing that robotic execution allowed highly precise restoration of joint-line height and individualized alignment targets.[23]

Andriollo et al. further expanded FA applications using an imageless robotic platform (ROSA®), demonstrating the value of real-time ligament tension analysis and iterative adjustment of component placement.[24]

Two studies focused specifically on FA in revision TKA. Braun et al. presented another imageless robotic technique for rTKA, individualizing femoral rotation, tibial slope, and joint-line position based on live assessment of ligament function, providing a reproducible strategy for personalized reconstruction in complex revisions.[25]

Migliorini et al. described a novel robotic-assisted rTKA workflow, reporting improved accuracy in reconstructing alignment and achieving soft-tissue balance when compared with traditional revision instrumentation.[26]

Across all included studies, personalized alignment strategies as KA, rKA, and FA were shown to be feasible in selected revision scenarios and UKA conversions, with consistent restoration of postoperative alignment, improved soft-tissue balance, and favorable clinical outcomes.[27] The principal characteristics of all included studies are summarized in Table 1 and Table 2.

4. Discussion

The most important finding of this scoping review is the growing evidence supporting the feasibility and early clinical promise of personalized alignment strategies, including kinematic alignment (KA), restricted kinematic alignment (rKA), and functional alignment (FA), in revision total knee arthroplasty (rTKA) and UKA to TKA conversions. While the technical feasibility of these approaches is increasingly well demonstrated across different surgical settings, the extent to which this translates into consistent and clinically meaningful patient benefit remains less clearly established. Across the available literature, these approaches consistently enabled restoration of patient-specific joint-line orientation and limb alignment, addressing symptomatic failures that

Table 1
Summary of included studies evaluating personalized alignment strategies (KA, rKA, FA) in revision TKA and UKA-to-TKA conversion.

First author (YoP)	Alignment strategy	Imaging	Technology	Type of study	Analysis (N)	Conclusion
Toliopoulos et al., 2016[19]	Anatomic alignment	Imageless	Conventional	Case series	21 UKA to TKA	Anatomic alignment preserved joint line and improved function compared to mechanical alignment
Howell et al., 2021	Kinematic alignment	Imageless	Conventional	Technical chapter + case study	1 rTKA	KA feasible in revision-like scenarios, allowing restoration of native joint-line orientation
Shelton et al., 2021[18]	Kinematic alignment	Imageless	Conventional	Case series	16 cases UKA to KA-TKA	Conversion to KA-TKA restored constitutional alignment with comparable outcomes to primary KA-TKA
Kostretzis et al., 2021[21]	Restricted KA (rKA)	Imageless	Conventional	Cohort study	43 rTKA	rKA feasible with safe boundaries; restored joint line and acceptable early outcomes
Sappey-Mariner et al., 2022[20]	Kinematic alignment	Imageless	Conventional	Case series	7 rTKA	KA restored constitutional limb alignment and improved PROMs in failed MA-TKA
Carlson et al., 2025[22]	Kinematic alignment	Imageless	Conventional	Technical note	1 rTKA	Restoration of joint-line obliquity in well-fixed failed TKA using KA principles
Ngim et al., 2023[15]	Functional alignment (FA)	Imageless	Robotic-assisted	Technical note + case series	19 rTKA	Robotic FA improved alignment accuracy and soft-tissue balancing in complex revisions
Mancino et al., 2024[23]	Functional alignment (FA)	CT-based	Robotic-assisted	Cohort study	16 UKA to TKA	Robot-assisted FA achieved precise joint-line and alignment restoration
Braun et al., 2025[25]	Functional alignment (FA)	Imageless	Robotic-assisted	Case series	1 rTKA	Personalized alignment based on ligament function feasible in robotic rTKA
Andriollo et al., 2025[24]	Functional alignment (FA)	Imageless	Robotic-assisted (ROSA®)	Cohort study	35 UKA to TKA	Imageless FA allowed dynamic balancing and individualized alignment reconstruction

Abbreviations.
KA, kinematic alignment; **rKA**, restricted kinematic alignment.
FA, functional alignment; **TKA**, total knee arthroplasty.
rTKA, revision total knee arthroplasty; **UKA**, unicompartmental knee arthroplasty.
YoP, year of publication.

Table 2
– Clinical and radiographic outcomes of personalized alignment in revision TKA and UKA to TKA conversion.

Author, year	N knees/ cases	Radiographic outcomes	Clinical outcomes (PROMs)	Range of Motion (ROM)	Complications/ Survivorship
Toliopoulos et al., 2016[19]	21	Significant LDFA/MPTA differences; no numerical values reported	WOMAC better in anatomic group; no values reported	Not reported	No complications or reoperations
Howell et al., 2021	1	Restoration of joint-line obliquity; no numerical values reported	Not reported	Not reported	Not reported
Shelton et al., 2021[18]	16	Postoperative alignment comparable to primary KA-TKA; no numerical values	OKS 39 in revisions (vs 43 primaries)	Not reported	100% survivorship (1–10 years)
Kostretzis et al., 2021[21]	43	HKA 0.8° varus; mDFA 1.7° valgus; mPTA 2.2° varus	WOMAC 34.4	Not reported	1 re-revision (2.3%); no loosening
Sappey-Mariner et al., 2022[20]	7	Constitutional alignment restored within 2°	KSS total +65.9	Flexion +30°	No instability; no constrained liners
Carlson & Scott, 2025[22]	1	Restoration of joint-line obliquity; no numerical values	Not reported	Not reported	No intraoperative complications
Ngim et al., 2023[15]	19	Radiographically satisfactory alignment; no numerical values	Not reported	Flexion ≈114°, full extension	No robot-related complications
Mancino et al., 2024[23]	16	Accurate alignment restoration; no numerical values	OKS ≈42; FJS ≈84	Not reported	No increased complications
Braun et al., 2025[25]	1	Personalized orientation; no numerical values	Not reported	Not reported	No complications reported
Andriollo et al., 2025[24]	35	Accurate limb alignment; no numerical values	OKS31 → 42; FJS 47 → 81	Not reported	97.1% survivorship

PROM = patient-reported outcome measures (e.g., OKS, KSS, WOMAC, FJS); values are reported only when explicitly available from abstracts or open-access full text, otherwise summarized qualitatively.

remained unresolved despite radiographically acceptable mechanical alignment (MA).[9,28,29]

In revision scenarios where the primary implant was aligned mechanically but symptoms persisted, KA-based strategies showed the ability to recreate a more physiological relationship between joint-line obliquity, ligament tension, and limb alignment. This supports the concept that technical correction toward a more anatomical alignment is achievable; however, evidence demonstrating that this correction consistently improves patient-perceived outcomes is still limited. These findings support the concept that a knee appearing "well aligned" according to traditional mechanical criteria may, in fact, be misaligned relative to the individual's native anatomy.[30,31] Evidence from comparative studies indicates that restoring constitutional alignment can improve stability, functional recovery, and patient satisfaction when MA fails to replicate natural knee biomechanics.[30] Nevertheless, these findings are derived from a limited number of heterogeneous studies, and should therefore be interpreted with caution when inferring true clinical superiority.

Similarly, in UKA to TKA conversions, applying anatomical or kinematic principles preserved the joint line more effectively and produced outcomes comparable to primary personalized TKA, reinforcing the importance of respecting each patient's pre-arthritic anatomy.[25,32] However, even in this setting, the distinction between achieving anatomical reconstruction and demonstrating a measurable improvement in patient-reported outcomes remains insufficiently explored.

An additional consideration relates to the interaction between implant design, fixation strategy, and achievable alignment in revision surgery. Traditional revision constructs rely heavily on long diaphyseal stems, which constrain component positioning and force surgeons toward mechanical alignment by limiting varus–valgus modulation and native joint-line recreation.[33,34] In contrast, the use of short, cemented stems with metaphyseal fixation provides greater freedom for personalized reconstruction and may expand the applicability of KA, rKA, or FA philosophies in revision settings.[34] These technical advancements further reinforce feasibility; however, whether this increased surgical flexibility leads to superior functional or patient-centered outcomes remains to be demonstrated.

Another emerging theme involves the potential role of robotic assistance in carrying out personalized alignment strategies. Robotic systems enable precise component placement based on patient-specific anatomy and provide intraoperative evaluation of ligament tension and gap balance potentially driving the level of constraint.[35] However, these measurements may be less reliable in revision knees due to bone loss and soft-tissue compromise.[26] Despite this limitation, robotics may offer objective quantification of joint-line orientation and overall limb alignment, assisting surgeons when conventional landmarks are deficient or distorted.[14,26] Importantly, while robotics clearly enhances the accuracy and reproducibility of implant positioning, there is currently insufficient evidence to confirm that this technical precision translates into improved clinical outcomes or patient satisfaction in the revision setting.

Several limitations persist across the current literature. Most studies are small, retrospective, and heterogeneous in technique, implant choice, and outcome reporting, while follow-up durations remain short. Importantly, the current evidence base is limited to a small number of studies (n = 10), further restricting the strength and generalizability of the conclusions. A major and recurring limitation is the inconsistent and often inadequate reporting of patient-reported outcome measures (PROMs). PROMs are inconsistently collected, and many revision implant designs still reflect mechanical alignment requirements rather than personalized strategies Moreover, PROMs reporting is highly variable across studies, often lacking standardization, completeness, and long-term follow-up. In many studies, PROMs are either absent, reported using non-standardized tools, or limited to short-term follow-up, significantly restricting the ability to determine whether personalized alignment provides a meaningful benefit from the patient's perspective. This represents a critical gap in the literature, as improvements in radiographic alignment or intraoperative balance do not necessarily correlate with patient satisfaction or functional recovery..[36,37]

Overall, personalized alignment appears both achievable and potentially advantageous in carefully selected revision cases. By restoring joint-line obliquity, limb alignment, and ligament tension toward constitutional values, personalized strategies may address symptomatic failures not resolved with MA. However, it is essential to clearly distinguish between what is surgically achievable and what is clinically beneficial: current evidence strongly supports feasibility, whereas robust data demonstrating consistent patient-centered benefit remain limited.

However, despite these encouraging findings, several limitations must be emphasized. First, evidence quality remains low, consisting predominantly of case reports, small case series, and retrospective cohorts. The predominance of retrospective designs and absence of high-level prospective or randomized studies significantly increase the risk of selection bias and limit causal inference. Many studies have limited follow-up, often restricted to the early postoperative period, preventing meaningful assessment of long-term survivorship or implant durability. In particular, the lack of consistent long-term survivorship data further limits the ability to assess the durability and clinical relevance of these techniques over time. Second, the heterogeneity in surgical philosophies, implant designs, robotic systems, and reporting methods significantly restricts direct comparison and precludes higher-level synthesis. This heterogeneity, combined with the limited number of available studies, also precluded the possibility of performing a formal meta-analysis, thereby limiting quantitative synthesis of the data. Third, PROMs were inconsistently reported, with some studies providing detailed functional assessments while others offered only qualitative descriptions or none at all. This limitation is particularly critical, as without robust and standardized PROMs, it is not possible to determine whether personalized alignment strategies truly result in superior outcomes compared with traditional mechanical alignment in revision TKA.

Future research should prioritize well-designed prospective studies and randomized controlled trials comparing MA, KA, rKA, and FA in revision scenarios. Particular emphasis should be placed on long-term functional outcomes, durability, and complication profiles, as well as ligament behavior and joint-line biomechanics, which remain poorly understood in the context of personalized revision surgery. Crucially, future studies must incorporate standardized and validated PROMs as primary endpoints rather than secondary or optional outcomes, in order to bridge the current gap between technical success and patient-perceived benefit. Incorporating standardized PROMs, radiographic parameters, and intraoperative soft-tissue metrics will be critical to allow meaningful comparisons across studies. Finally, cost-effectiveness analyses and workflow studies will help determine the practicality and scalability of robotics-enabled personalized alignment in various healthcare environments.

In summary, early evidence indicates that personalized alignment strategies, especially when supported by robotic technology, are feasible and potentially advantageous in revision TKA and UKA to TKA conversion. These strategies allow restoration of patient anatomy, improve functional outcomes, and may reduce reliance on soft-tissue releases. Nevertheless, current literature more robustly supports technical feasibility than definitive clinical benefit. However, substantial gaps in evidence quality, implant constraints, and lack of long-term data must be addressed before widespread adoption can be recommended. In particular, the absence of consistent, high-quality PROMs reporting remains a major barrier to confirming the true clinical value of these approaches. Continued innovation in both surgical technique and implant design, paired with rigorous research, will be essential to fully realize the promise of personalized alignment in revision knee arthroplasty.

5. Conclusion

This scoping review indicates that personalized alignment strategies, including kinematic alignment (KA), restricted kinematic alignment (rKA), and functional alignment (FA), have been reported as technically feasible in selected revision TKA and UKA to TKA conversion procedures. Across the included studies, these philosophies demonstrated the ability to restore patient-specific joint-line orientation and constitutional limb alignment, offering a biomechanically intuitive alternative to traditional mechanical alignment. However, while technical feasibility is consistently supported, the extent to which these approaches provide a reproducible and clinically meaningful benefit remains unproven. Early clinical findings consistently reported improvements in range of motion and patient-reported outcomes without an increase in complications, although these findings should be interpreted with caution given the limited quality and heterogeneity of the available evidence.

Important technical considerations emerged from the review. Current revision implant designs frequently rely on diaphyseal fixation, which constrains component orientation and limits the surgeon's ability to reproduce individualized alignment targets. In contrast, metaphyseal fixation with short cemented stems may provide greater flexibility for restoring native anatomy. Robotic assistance also appears valuable, offering precise control of component positioning and objective assessment of alignment parameters, although soft-tissue measurements may be less reliable in the presence of bone loss or ligamentous insufficiency common in revision settings. Despite these technological and technical advantages, there is currently insufficient evidence to confirm that improved accuracy in implant positioning translates into superior patient outcomes.

Despite these encouraging insights, the available evidence remains limited by small sample sizes, heterogeneous study designs, and short-term follow-up. As such, significant evidence gaps remain. Additional prospective studies, longer-term data, and implant systems specifically designed to support alignment personalization will be essential to determine the long-term clinical value and broader applicability of these strategies. In particular, high-quality studies incorporating standardized patient-reported outcome measures and survivorship data are needed to clarify whether the theoretical and technical advantages of personalized alignment result in tangible clinical benefit. Personalized alignment has the potential to enhance outcomes in revision knee arthroplasty, but its clinical superiority over traditional approaches has not yet been definitively demonstrated, and further robust evidence is needed to define its definitive role.

Guardian/patient's consent

Not applicable, as this study is a review article and did not involve human participants.

Credit author statement

Conceptualization, S.R. and M.C.; methodology, S.R and M.C; validation, S.S. and G.B.; formal analysis, G.B. and S.S.; investigation, S.R.; writing—original draft preparation, S.R. and M.C; writing—review and editing, G.B and S.S; visualization, P.F.I; supervision, M.C.; project administration, A.M. All authors have read and agreed to the published version of the manuscript.

Ethical statement

Ethical approval was not required for this study, as it is a scoping review of previously published literature and did not involve human or animal subjects.

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Declaration of competing interest

The authors declare that they have no competing interests.

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