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Review

Comparative efficacy of the different cutting guides in unicompartmental knee arthroplasty: A systematic-review and network meta-analysis

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ABSTRACT

Background: Several cutting guides including conventional, navigation, patient specific instrumentation (PSI) and robotic are currently used in unicompartmental knee arthroplasty (UKA). A network meta-analysis was conducted to compare the most widely used cutting guides regarding the improvement of radiological, functional outcomes and the rate of complications.
Methods: Randomised controlled trials (RCTs) comparing UKA cutting guides were searched in electronic databases, major orthopaedics journals, and oral communications in major orthopaedics meetings, until May 1st, 2022. The primary outcomes were the rate of outliers for the tibial and femoral components in the frontal plane, KSS score and the complication rate.
Results: Eighteen RCTs involving 1562 patients with 1564 UKA were included Regarding the prosthetic components' positions, we found a significant increase of the outliers rate using PSI for the femoral component, compared to robotic surgery (risk ratio 0.00 [95% CI 0.00 to 0.55]) and navigated surgery (risk ratio 305.1 [95% CI 1.50 to 1,27e + 07]). We didn't emphasize any difference regarding the tibial component's position, the KSS value at 24 months postoperatively, and the complication rate. Regarding secondary outcomes, robotics provided a better precision in bone cuts in the sagittal plane for the tibial component and the lower limb alignment. No other differences were observed.
Conclusion: In the light of these results, the robot seems to be the most precise cutting instrument to perform UKA. However, this did not demonstrate any difference in functional or clinical outcome. The cost of this technology can be a major economic brake, especially in surgical centers that do not have an exclusive prosthetic activity. Further outcome and survivorship data is needed to recommend one cutting instrument over the other.

Contents

1. Introduction 73
2. Materials and methods 73

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2.1. Search strategy . . . 73
2.2. Study eligibility and selection process . . . 74
2.3. Selection and general network characteristics . . . 75
2.4. Data extraction and risk of bias assessment . . . 75
2.5. Data synthesis and analysis . . . 75
3. Results . . . 76
3.1. Outliers of the femoral and tibial component on frontal plane . . . 76
3.2. KSS within one- and two-years post-surgery . . . 77
3.3. Rate of complications . . . 77
3.4. Secondary outcomes . . . 77
3.5. Grade evaluation . . . 77
4. Discussion . . . 78
5. Conclusions . . . 80
Ethical approval . . . 80
Consent to Participate . . . 81
Consent to publish . . . 81
Authors' contribution . . . 81
Funding . . . 81
Availability of data and materials . . . 81
Declaration of Competing Interest . . . 81
Appendix A. Supplementary material . . . 81
References . . . 81

1. Introduction

In sixty percent of patients suffering from knee osteoarthritis, cartilage wear is isolated to a single compartment. In the majority of cases, the internal femoro-tibial compartment is the altered one. However, Unicompartmental Knee Arthroplasty (UKA) still accounts for only 8–12% of all knee replacements [1–3]. In good cases, UKA had better functional results than Total Knee Arthroplasty (TKA) [4]. These advantages include improved postoperative range of motion, proprioception, preservation of bone stock, quicker recovery and better patient satisfaction [5–10]. In recent years, there has been a recent increase of UKA implantations, especially in the United States of America [11,12]. This change is attributable to a better understanding of the indications and to the development of new technologies. In particular, the bone cutting guides used to perform the arthroplasty have shown a great improvement.

The development of new technologies in the medical sector and particularly in prosthetics surgery is always attractive as much for the physician as for the patient. Despite, sometimes, the commercial pressure and the passing fad, it is always important to assess the benefit/risk balance of innovations and their real contribution for the surgeon and above all, for the patient.

Numerous therapeutic trials or meta-analyzes comparing these different cutting guides in UKA two by two have been carried out [13–16]. They find contradictory results or sometimes advocate a lack power to find any difference between the cutting guides, due to the low volume of the series. In addition, no study has simultaneously compared these different cutting guides to each other.

Network meta-analyses (NMA) allow the comparison of treatments that were not evaluated directly against each other in individual trials [17]. Therefore, it is a powerful tool to answer an important question when multiple treatment options are available.

To compare the different available cutting guides, we performed a NMA to determine whether the conventional cutting guide, Patient Specific Instrumentation (PSI) or Navigation or Robotic provided any advantages in terms of: [1] rate of outliers in frontal plan [2] clinical outcome scores, [3] the surgical time [4] and other secondary outcomes.

2. Materials and methods

This systematic review and NMA was registered in PROSPERO (Number CRD42021251738) and is reported in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) statement.

2.1. Search strategy

We searched all RCTs available in electronic databases (Medline, CENTRAL and Embase) starting at the inception date up to April 1, 2022, using dedicated search equations adapted to each database (Appendix 1). We manually searched major international orthopaedic journals (the *Journal of Bone and Joint Surgery American Volume*, the *Journal of Arthroplasty*, *Bone Joint Journal* and *Clinical Orthopaedics and Related Research*®) and conference proceedings of orthopaedic meetings (the American Academy of Orthopaedic Surgeons, the American Association of Hip and Knee Surgeons, and the Société Française de Chirurgie Orthopédique et Traumatologie) from January 1, 2010 to April 1, 2022. We also searched ClinicalTrials.gov and the World Health Organization's International Clinical Trials Registry Platform. Finally, we systematically screened reference lists of systematic reviews and meta-analyses for any additional references.

2.2. Study eligibility and selection process

All RCTs that compared at least two different cutting guides and reported at least one of our mentioned outcomes were included. No restriction on language or date of publication was applied. Exclusion criteria were UKA for another indication than osteoarthritis or femoro-patellar prostheses.

Three main types of outcomes were assessed in this review: the proportion of outliers in frontal plane for tibial and femoral component, the Knee Society Score (Both new and old) between one and two years postoperatively and the rate of complications.

Secondary radiological outcomes, measured on knee X-rays at 6 months postoperatively were: the proportion of HKA outliers; misalignment of tibial and femoral implants in sagittal and axial plane. Other secondary clinical outcomes were assessed: the mean blood loss;the mean Range of Motion (ROM) at 6 months and at 1 and 2 years postoperatively and after two years, KSS at 6 months and after two years postoperatively, Western Ontario et McMaster (WOMAC) score at 6 months and at 1 and 2 years postoperatively and after two years, Oxford Knee Score (OKS) score at 6 months and at 1 and 2 years postoperatively and after two years, Short Form 12 health survey (SF12) at 6 months and at 1 and 2 years postoperatively

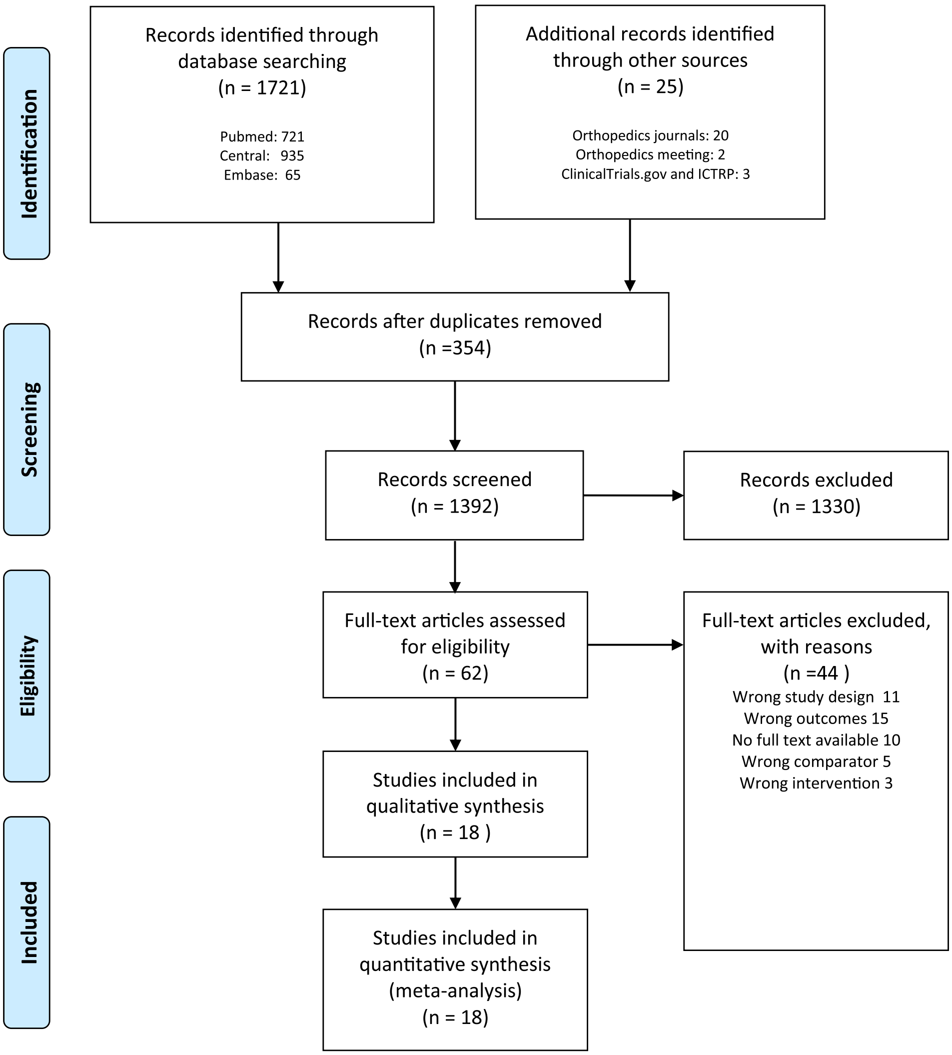

Figure 1. This PRISMA flow chart shows the selection process of the network meta-analysis comparing the efficacy of different cutting guides in UKA.

and after two years, Forgotten Joint Score (FJS) at 6 months and at 1 and 2 years postoperatively and after two years, the rate of revisions and the mean surgical time.

Two reviewers independently screened titles, summaries, and full texts whenever necessary to assess the eligibility of each study. Disagreements were resolved by a third reviewer and by contacting the corresponding author in case of persisting doubt.

2.3. Selection and general network characteristics

Our search initially retrieved 1746 records. Finally, 18 RCTs with 1562 patients and 1564 knees were included (Figure 1). The most frequent comparison was conventional versus navigation in 8 of 18 (44.4%). The characteristics of included studies is available on Appendix 2. The global network diagram illustrates that conventional cutting guide were compared with every other technique (Figure 2). The risk of bias of each study remains heterogeneous notably concerning the "sequence generation" and "allocation concealment" (Appendix 3).

2.4. Data extraction and risk of bias assessment

The same reviewers independently extracted data and evaluated the risk of bias using the Cochrane risk-of-bias tool [18] in a dedicated data extraction form that was tested on 10 random records. In case of disagreement, a third reviewer was involved to reach consensus.

Following data was collected: general study information; characteristics of the study; population characteristics; surgical approaches; prothesis; specific surgical; and results for outcomes of interest. Regarding continuous outcomes, means or SD were estimated from the median and the first and third quartiles and/or ranges using approximation formulas [19,20] when not available (Appendix 4). The corresponding authors were contacted in case of missing data.

2.5. Data synthesis and analysis

The unit of analysis was the knee. Binary outcomes were compared using risk ratios (RR). Continuous outcomes were compared using mean differences (MD) with 95% credible intervals (CIs). For direct comparisons, we conducted a conventional meta-analysis to synthesize the results, using random-effects models and fixed-effects models as sensitivity analyses. We combined direct and indirect comparisons via a NMA using the hierarchical model of Lu and Ades [21] with a Bayesian approach. In a Bayesian framework, estimates are based on the mean of the posterior distribution of the endpoint and are called credible intervals (Cis). Usually, the 95% CI corresponding to the interval that has a posterior probability of 95% that the endpoint lies within it. Unlike the frequentist approach, the Bayesian approach does not allow the calculation of the p value. Conclusions are drawn from whether or not 1 (which corresponds to a no-difference relative risk) or 0 (which corresponds to no mean differences) belongs or not to the credible interval. We used Markov Chain Monte Carlo to implement the model. Beta non-informative prior distribution was used for dichotomous outcomes and normal non-informative prior distribution was used for continuous outcomes [22]. The model's convergence was assessed using Brooks-Gelman-Rubin plots [23]. We evaluated the fit via residual deviance [24]. We checked the assumption of transitivity by considering similarity in the distribution of age, sex, and BMI across the different pairwise comparisons. A network diagram was used for each prespecified outcome to present direct comparisons between interventions. We obtained a treatment hierarchy using the surface under the cumulative ranking curve and mean ranks. To infer the assumption of inconsistency, we used a node-splitting

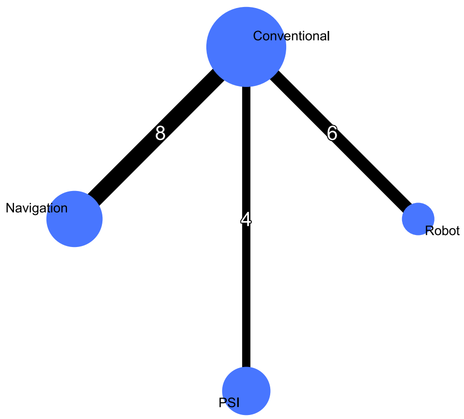

Figure 2. In this global network diagram, the nodes (circles) represent different cutting guides, and their sizes were proportional to the sample size of each respective intervention. The edges (lines) indicate direct comparisons, and their thicknesses were proportional to the number of studies available.

approach [25], and we compared the fit between the consistency and inconsistency models. We statistically assessed the presence of heterogeneity within each network comparison using the I^2 statistic. We used the GEMTC R-package (version 0.8–2) for analyses and netmeta R-package (version 0.9–8) for network diagrams in R version 3.5.2 software (R foundation for statistical Computing, Vienna, Austria). The quality of evidence for the main outcomes was evaluated using the GRADE framework [26].

3. Results

All pairwise comparisons are available on Appendix 5.

3.1. Outliers of the femoral and tibial component on frontal plane

Seven studies (38.8%) reported the rate of outliers for femoral and tibial component on the frontal plane (Figure 3a and b). For the femoral component, the rate of outliers was lower in the robotic group than in the PSI group (risk ratio 0.00 [95% CI 0.00 to 0.55]) and greater in the PSI group than in the navigation group (risk ratio 305.1 [95% CI 1.50 to 1,27e^{+07}]), with I^2 = 0.0% (Figure 4). Robot had the highest probability of having the lowest proportion of outlier in frontal plane for the femoral component (Figure 5a). For the tibial component, no differences between the different cutting guides were found with I^2 = 4.0% (Figure 6). PSI had the highest probability of having the lowest proportion of outlier in frontal plane for the tibial component (Figure 5b).

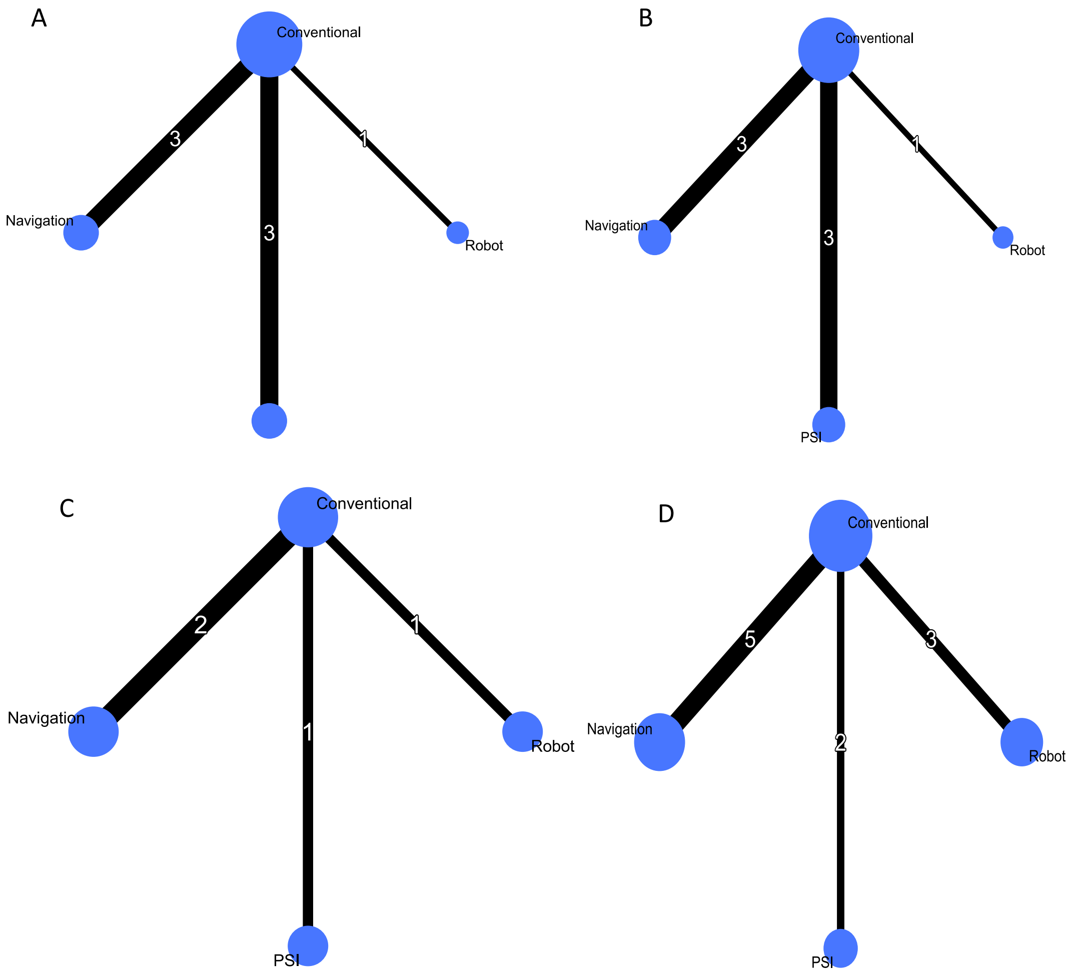

Figure 3. A-D These network diagrams of the main outcomes show (A) Rate of outliers for femoral component in frontal plane, (B) Rate of outliers for tibial component in frontal plane, (C) KSS between one- and two-years post-surgery, (D) rate of complications.

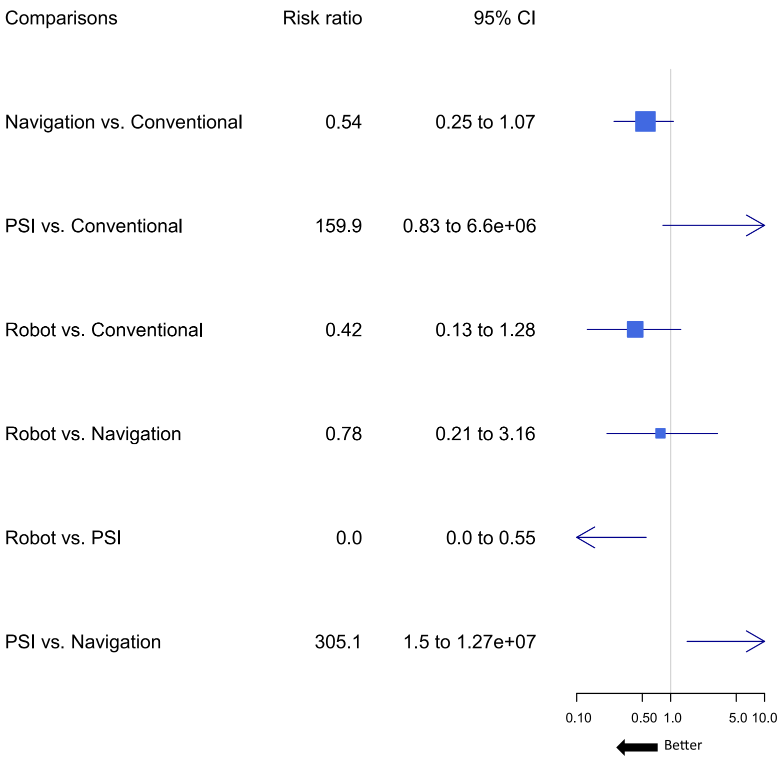

Figure 4. Forest plots in the network meta-analysis of the rate of outliers for femoral component in frontal plane. The data are presented as the risk ratio with 95% credibility intervals, which were obtained using random effects models. The I^2 of the network meta-analysis was 0.0%.

3.2. KSS within one- and two-years post-surgery

Four studies (22.2%) reported the KSS score within one- and two- years post-surgery (Figure 3c). We found no differences between the different cutting guides with I^2 = 1.0% (Figure 7). Robot had the highest probability of leading to the highest KSS mean values (Figure 5C), although no significant differences were found.

3.3. Rate of complications

Ten studies (45.5%) reported the surgical time (Figure 3d). We found no differences between the different cutting guides with I^2 = 0.0% (Figure 8). The robot guide had the highest probability of having the lowest rate of complication,ns (Figure 5d), although no significant differences were found. The details of complications is available on Appendix 6.

3.4. Secondary outcomes

Regarding HKA angle, rate of outliers was lower in the robotic group than in the conventional guide group (risk ratio 0.00 [95% CI 0.00 to 0.01]) and than in the navigation group (risk ratio 0.00 [95% CI 0.00 to 0.02], Appendix 7). Regarding the rate of outliers in sagittal plane for the tibial component, the proportion was lower in the robotic group and in the navigation group than in the conventional guide group (respectively, risk ratio 0.26 [95% CI 0.10 to 077] and risk ratio 0.41 [95% CI 0.17 to 0.97], Appendix 7). Concerning the other secondary radiological outcome, found no differences between the different cutting guides. Regarding at 6 months, between one- and two years and after two years post-surgery, we found no differences between the different cutting guides fort the KSS score, OKS score, the WOMAC score, the Joint Forgotten Score, the SF-12 and for the range of motion (Appendix 8). Blood loss was not different between groups. Finally, regarding the rate of revision and the mean surgical time, no differences were observed (Appendix 9).

3.5. Grade evaluation

We performed the GRADE evaluation for the three main outcomes. For the rate of outliers in frontal plane, it indicates that the evidence is moderate for PSI/conventional and low for other comparisons (Appendix 10). For the KSS between one- and two-years, it suggests that the evidence is moderate for PSI/conventional and high for other comparisons (Appendix 10). For the complication rate, it suggests that the evidence is high PSI/conventional and moderate for other comparisons (Appendix 10).

4. Discussion

No study directly compared navigation to robot or PSI and no study directly compared PSI to robot. Network meta-analyses allowed us to indirectly obtain information on these unrealized comparisons. This study therefore provides new information compared to the existing literature.

The robot is ranked first in all radiological outcome except for the position of the tibial implant in the frontal plane, in 86% of cases. It seems, therefore, that robotics brings precision to the realization of bone cuts in the three planes of space. Furthermore, no difference was found in the different clinical scores at the short, medium and long term. However, experience and technical performance have been reported as parameters that influence clinical outcomes as well as survival in UKA [27–29]. In this regard, new technologies, that improve accuracy may play a role in survival as well as clinical success for lower volume surgeons. This was recently suggested by the Australian registry after three years of follow-up [30].

We have chosen not to give a definition concerning the outliers for the radiological outcome because it depends on the objectives and beliefs of the surgeon. Indeed, currently, new definitions of alignment objectives are multiplying [31]. This choice, not to define them, allowed us to increase the amount of information available but has the disadvantage of making the results more heterogeneous. However, the goal, to assess outlier rates, is to try and show whether a cutting guide is more accurate within the goals set by the surgeon. This is a guarantee of external validity. The lack of more concrete results can be explained, on the clinical outcomes. First, there is a multitude of clinical scores and no recommendation on which score to use in each pathology. Moreover, the multiplicity of clinical scores and times of collection means that there is a huge loss of information. There is no consistency in patient follow-up. However, it seems difficult for a surgical team to regularly and frequently review all the patients operated on without overloading its consultations and continuing to consult new patients [32]. This highlights the mandatory need to homogenize and develop recommendations on the judgment criteria to be col-

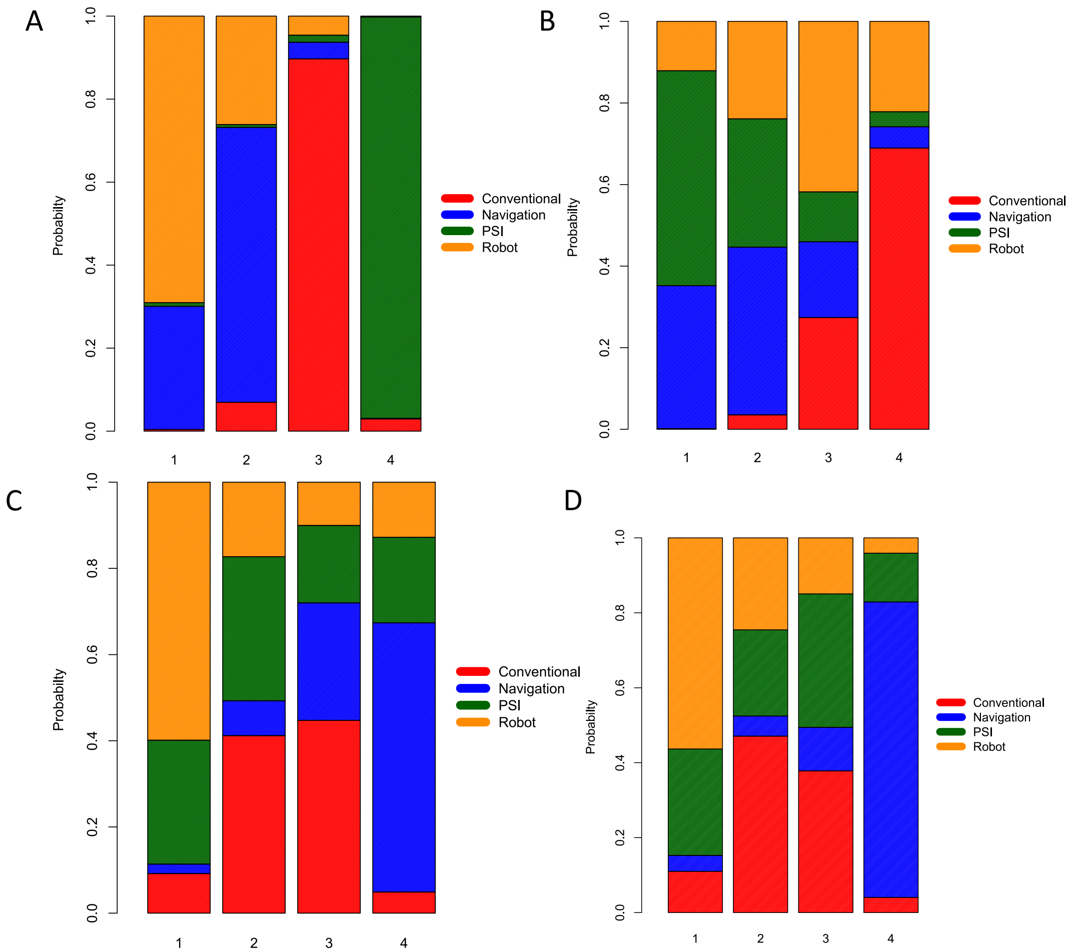

Figure 5. A-D These images shows rank probabilities of (A) outlier of femoral component in frontal plane, (B) outlier of tibialcomponent in frontal plane, (C) KSS between one- and two- years post-surgery and (D) rate of complications for each cutting guides. The × axis represents the ranking. The y axis represents the probability of rank: 0% to 100%. Each color represents one cutting guide: red for conventional, blue for navigation, green for PSI and orange for robot.

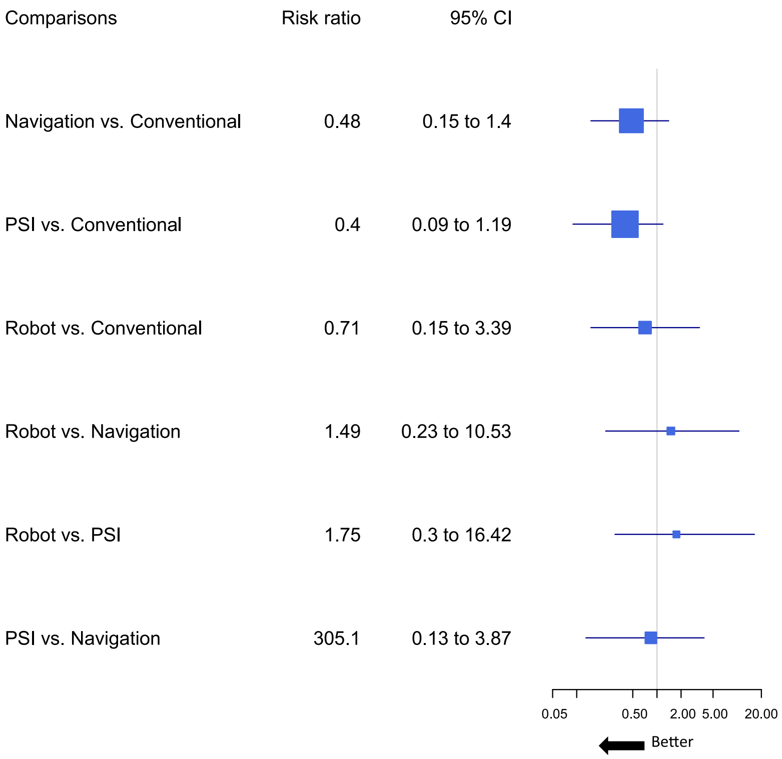

Figure 6. Forest plots in the network meta-analysis of the rate of outliers for tibial component in frontal plane. The data are presented as the risk ratio with 95% credibility intervals, which were obtained using random effects models. The I^2 of the network meta-analysis was 4.0%.

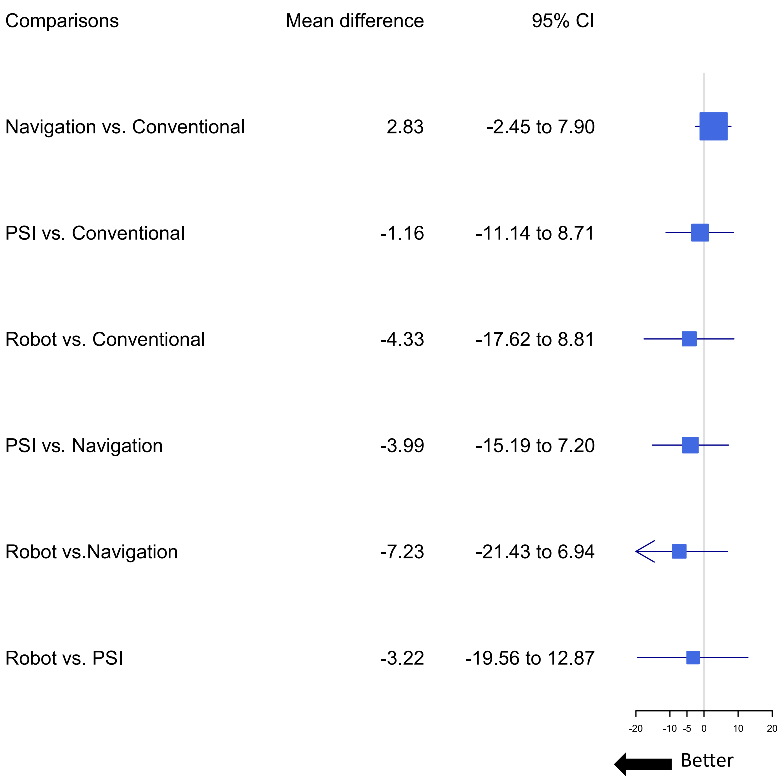

Figure 7. Forest plots in the network meta-analysis of the mean difference of KSS between preoperatively and one/two years postoperatively. The data are presented as the relative mean differences with 95% credibility intervals, which were obtained using random effects models. The I^2 of the network meta-analysis was 1%.

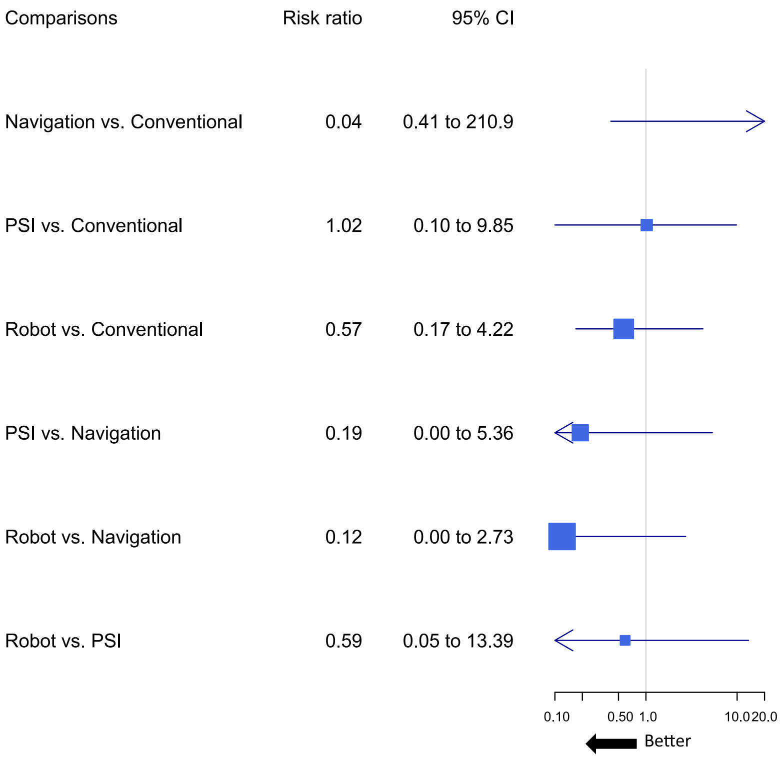

Figure 8. Forest plots in the network meta-analysis of the rate of complications. The data are presented as the risk ratio with 95% credibility intervals, which were obtained using random effects models. The I^2 of the network meta-analysis was 0.0%.

lected in studies in orthopaedic and especially in prosthetic surgery as recommended by the Core Outcome Measures in Effectiveness Trials (COMET) group [33]. Second, the function is a subjective assessment of the patient on his condition and several parameters come into play. The future function of a prosthetic joint cannot be reduced to the use of a technological tool, other factors depending on the patient, the pathology and the technique influence the final evaluation. The preoperative, intraoperative and postoperative environment play a role and differ between studies [34,35]. Finally, it would be necessary to know from which difference observed between the preoperative and the postoperative, for a given score, this becomes relevant for the patient. There are interesting statistical methods for this, which are increasingly being developed in orthopedics, namely MCIDs (minimal clinically important difference) [36]. MCIDs are used in clinical research as a decision threshold to test the effectiveness of a new treatment compared to current practices [37].

Robotic and computer navigation technology is increasingly used in arthroplasty [38]. In a previous paper, studying cutting guides for total knee replacements, the robot seemed to provide accuracy, but this difference could not be demonstrated due to the lack of data in the literature [2]. However, a recent study comparing the results of the robot with a mechanical ancillary, with a minimum follow-up of 10 years, found no difference [11]. In addition, it has recently been shown that between 2500 and 4000 TKAs would be required in each arm of a study to have an 80% chance of reducing revision rates at 15 years [39].Additional data is therefore necessary in order to really prove the interest or not of robotics in TKA surgery. Similar data are needed for UKA given the difference in technical results and the differences in survival observed [40].

5. Conclusions

Despite the fact that no difference was observed on the clinical endpoints, robotics provides precision in bone cuts in the frontal plane for the femoral component, in the sagittal plane for the tibial component and in alignment end of the lower limb. In addition, no difference was found in the rates of complications and revision and in the duration of the operation.

The cost of robotic technology can be a major economic break and therefore further studies that demonstrate clinical outcome and improve survivorship, are required in order to recommend robotic cutting instruments for UKA surgery.

Ethical approval

Patients were not involved in any aspect of the study design, conduct, or development of the research question or outcome measures. This study is a systematic review and NMA of existing published research. Thus, there was no active patient recruitment for data collection.

Consent to Participate

No necessary.

Consent to publish

All authors gave their consent to publish the study.

Authors' contribution

- Pierre-Alban Bouché: Article design, data collection and analysis and article writing.
- Simon Corsia: Data collection and proofreading.
- Aurélien Hallé: Data analysis and proofreading.
- Nicolas Gaujac: Data collection and proofreading.
- Rémy Nizard: Article design, article writing.

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Availability of data and materials

Datas are available on requests.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Appendix A. Supplementary material

Supplementary data to this article can be found online at https://doi.org/10.1016/j.knee.2023.01.003.

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