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Original Research Article

PATELLA HEIGHT INFLUENCES PATELLOFEMORAL CONTACT AND KINEMATICS IN ROBOTIC VS MANUAL CRUCIATE RETAINING TOTAL KNEE REPLACEMENT

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ABSTRACT

Background: A proportion of patients report persistent symptoms and dissatisfaction after total knee arthroplasty (TKA), and patellofemoral-related complaints remain an important contributor to suboptimal outcomes. Patellar height is a key determinant of extensor mechanism biomechanics and may influence patellofemoral contact mechanics and kinematics after cruciate-retaining total knee replacement (CR-TKR). Robotic-assisted TKA has been introduced to improve reproducibility of component positioning and restoration of anatomical parameters, which may affect patellar height and patient-reported outcomes. The aim is to evaluate the influence of patellar height on patellofemoral contact and kinematics after CR-TKR, and to compare patellar height restoration and functional outcomes between robotic-assisted and manual techniques.

Materials and Methods: This prospective analytical study included 500 knees undergoing CR-TKR, comprising 250 manual and 250 robotic-assisted cases. Postoperative patellar height was assessed using the Blackburne Peel (BP) ratio. Functional outcome was evaluated using the Forgotten Joint Score-12 (FJS-12) at a minimum follow-up of one year. Patellar height distribution (baja/normal/alta) and the association between BP ratio and FJS-12 were analyzed. Statistical significance was set at $p < 0.05$.

Results: Baseline characteristics were comparable between the groups. The robotic-assisted group demonstrated a significantly higher mean BP ratio compared with the manual group (0.66 ± 0.06 vs 0.62 ± 0.07; $p = 0.003$). Mean FJS-12 was significantly higher in the robotic-assisted cohort (71.4 ± 11.6) compared with the manual cohort (63.1 ± 12.8; $p < 0.001$). Patella baja was more frequent in the manual group than the robotic-assisted group (16.7% vs 6.7%). Subgroup analysis showed lower FJS-12 scores in patella baja compared with normal patellar height in both groups. BP ratio demonstrated a moderate positive correlation with FJS-12 ($r = 0.34$; $p < 0.001$).

Conclusion: Patellar height restoration is associated with patient-reported joint awareness following CR-TKR. Robotic-assisted CR-TKR demonstrated improved restoration of patellar height and higher FJS-12 compared with manual CR-TKR. Optimizing patellar height may contribute to improved functional integration after cruciate-retaining total knee replacement.

Keywords: Patella height; Blackburne–Peel ratio; Forgotten Joint Score-12; Robotic-assisted total knee replacement; Manual total knee replacement; Cruciate-retaining.

INTRODUCTION

Total knee arthroplasty (TKA) is a well-established and effective procedure for end-stage knee osteoarthritis, providing substantial pain relief and improvement in function for the majority of patients. However, despite advances in implant design, surgical technique, and perioperative care, a proportion of patients continue to report persistent symptoms and dissatisfaction after surgery. Patellofemoral-related complaints such as anterior knee pain, crepitus, and reduced satisfaction during activities involving knee flexion remain clinically relevant, and are increasingly recognized as important contributors to suboptimal patient-perceived outcomes following TKA.[1]

Patellar height is a key determinant of extensor mechanism biomechanics and has been shown to influence patellofemoral contact mechanics and tracking patterns after cruciate-retaining total knee replacement. Abnormal patellar height can alter patellofemoral contact forces and kinematics across the range of motion, potentially increasing joint stress and affecting functional performance after surgery.[1] Radiological assessment of patellar height and joint line position before and after TKA is therefore important in evaluating postoperative patellofemoral mechanics, and newer radiographic approaches have been proposed to improve accuracy in these measurements.[2]

A reduction in functional patellar height after arthroplasty can occur not only due to true patella baja but also due to changes in the joint line, resulting in pseudo-patella baja. This condition is clinically important because it may be associated with altered patellar tracking, increased patellofemoral contact load, and functional impairment. Radiological evaluation of pseudo-patella baja has demonstrated that it may have meaningful clinical consequences and may contribute to persistent symptoms following TKA.[3] In long-term follow-up studies, significant reductions in patellar height after TKA have been associated with poorer clinical outcomes and reduced knee flexion, emphasizing the importance of preserving or restoring appropriate patellar height during surgery.[4]

Joint line changes and patella baja have also been shown to influence functional results in revision TKA, reinforcing the broader importance of patellofemoral mechanics across both primary and revision arthroplasty settings.[5] In addition, patellar mobility itself an important functional correlate of patellofemoral mechanics has been reported to be reduced in patients undergoing knee arthroplasty compared with healthy knees, suggesting that patellofemoral functional behavior is altered even beyond static radiographic changes.[6] From a patient-reported perspective, contemporary outcome measures such as the Forgotten Joint Score-12 (FJS-12) have gained popularity because they capture subtle "joint awareness," which may reflect ongoing patellofemoral symptoms and incomplete functional integration of the prosthetic joint. The minimal important difference for the FJS-12 has been established, supporting its clinical applicability and interpretability in TKA outcome research.[7]

Given the influence of patellar height on patellofemoral contact forces and kinematics, along with its association with clinical outcomes after TKA, further evaluation of patellar height restoration is warranted. This is particularly relevant when comparing newer technologies such as robotic-assisted TKA with conventional manual techniques, as improved reproducibility in component positioning and joint line restoration may influence postoperative patellar height and patient-perceived outcomes. Therefore, this study aims to assess patellar height using the Blackburne–Peel ratio and evaluate its association with patient-reported outcome using the FJS-12 in patients undergoing robotic-assisted versus manual cruciate-retaining total knee arthroplasty.

Aim

To evaluate the influence of patellar height on patellofemoral contact and kinematics after cruciate-retaining total knee replacement and to compare patellar height restoration and functional outcomes between robotic-assisted and manual techniques.

Objectives

1. To assess postoperative patellar height using the Blackburne Peel ratio in patients undergoing robotic-assisted and manual cruciate-retaining total knee replacement.
2. To determine the prevalence of patella baja and pseudo-patella baja after robotic-assisted and manual cruciate-retaining total knee replacement.
3. To compare patient-reported functional outcomes between the robotic-assisted and manual groups using the Forgotten Joint Score-12 (FJS-12) at a minimum follow-up of one year.
4. To evaluate the association between patellar height and postoperative functional outcome (FJS-12) following cruciate-retaining total knee replacement.

Hypothesis

1. Patellar height influences patellofemoral contact and kinematics after cruciate-retaining total knee replacement, and reduced patellar height (patella baja/pseudo-patella baja) is associated with inferior postoperative functional outcomes.
2. Robotic-assisted cruciate-retaining total knee replacement results in more consistent restoration of patellar height compared with manual cruciate-retaining total knee replacement, leading to improved patient-reported outcomes (FJS-12).

MATERIALS AND METHODS

Study Design: This study was designed as a prospective analytical study comparing patellar height and patient-reported functional outcomes in individuals undergoing robotic-assisted versus

manual cruciate-retaining total knee replacement (CR-TKR).

Robotic-assisted TKA has been increasingly adopted due to improved reproducibility in component placement, alignment, and rotational accuracy, potentially improving patellofemoral mechanics and functional outcomes. Randomized controlled trials and systematic reviews have demonstrated that robotic-assisted TKA can improve accuracy of component positioning and radiographic alignment parameters when compared with conventional manual techniques. (8-12)

Study Setting and Duration: The study was conducted at the Centre for Robotic Joint Replacement, Sarvodaya Hospital and Research Centre, Sector-8, Faridabad, India, the study was conducted between October 2023 and December 2025.

Sample Size

A total of 500 knees were planned for inclusion in the study, distributed as:

- 250 robotic-assisted CR-TKR
- 250 manual CR-TKR

Study Population: All consecutive eligible patients undergoing primary cruciate-retaining total knee replacement during the study period were considered for inclusion.

Eligibility Criteria

Inclusion Criteria

- Patients undergoing primary cruciate-retaining total knee replacement
- Postoperative knee range of motion between 10° and 90°
- Minimum 1-year postoperative follow-up
- Ability to complete the Forgotten Joint Score-12 questionnaire

Exclusion Criteria

- Active knee infection
- Postoperative knee infection
- Previous surgery around the knee
- Traumatic deformity
- Malunited fractures involving the tibia
- Tibial tuberosity avulsion
- Patellar tendon injury

These conditions were excluded as they could significantly alter patellofemoral biomechanics and confound assessment of patellar height and functional outcomes.

Group Allocation

Patients were classified into two groups based on the surgical technique used:

- **Group 1 (Robotic-assisted CR-TKR):** Patients undergoing robotic-assisted cruciate-retaining total knee replacement
- **Group 2 (Manual CR-TKR):** Patients undergoing manual cruciate-retaining total knee replacement

Surgical Technique and Perioperative Protocol: All procedures were performed under standardized operating room protocols and uniform perioperative care pathways. Robotic-assisted CR-TKR cases were performed using a robotic platform, while manual CR-TKR cases were performed using conventional instrumentation.

Robotic systems in total knee arthroplasty have been reported to restore alignment parameters accurately and achieve satisfactory clinical outcomes, while also reducing the likelihood of surgical outliers. (8,9) Systematic reviews and meta-analyses of randomized controlled trials have further supported that robotic-assisted techniques provide improved precision in radiographic alignment compared with conventional TKA. (10–12)

Data Collection

Patient demographic and clinical data were recorded, including:

- Age
- Sex
- Height
- Weight

Radiographic and outcome variables recorded included:

- Blackburne-Peel ratio (postoperative patellar height)
- Forgotten Joint Score-12 (FJS-12) (functional outcome)

Radiographic Evaluation of Patellar Height

Postoperative patellar height was assessed using the Blackburne–Peel (BP) ratio on standardized lateral knee radiographs. Patellar height was classified as:

- Patella baja: BP ratio < 0.50
- Normal patellar height: BP ratio 0.50–1.00
- Patella alta: BP ratio > 1.00

Functional Outcome Assessment: Functional outcomes were evaluated using the Forgotten Joint Score-12 (FJS-12), which measures the patient's degree of joint awareness during daily activities. FJS-12 has been increasingly used as a sensitive patient-reported measure capable of detecting subtle differences in satisfaction and functional integration after TKA.

Follow-up: Patients were followed for a minimum of one year, with an average follow-up duration of 14 months. At final follow-up, radiographic patellar height assessment and FJS-12 scoring were documented.

Outcome Measures

Primary Outcome

- Forgotten Joint Score-12 (FJS-12) at minimum 1-year follow-up

Secondary Outcomes

- Blackburne–Peel ratio (patellar height) comparison between robotic and manual groups
- Proportion of patella baja / normal / alta in each group
- Association between patellar height (BP ratio) and functional outcome (FJS-12)

Statistical Analysis: Data were entered into a spreadsheet and statistically analyzed. Continuous variables were expressed as mean ± standard deviation, while categorical variables were expressed as frequency and percentage. Group comparisons were performed between robotic-assisted and manual groups for radiographic and functional outcomes. A

p-value < 0.05, with a 95% confidence interval, was considered statistically significant.

Robotic and conventional TKA outcomes were compared keeping in view evidence from randomized controlled trials and systematic reviews suggesting radiographic improvements and comparable-to-improved early clinical outcomes following robotic-assisted TKA.[8–12]

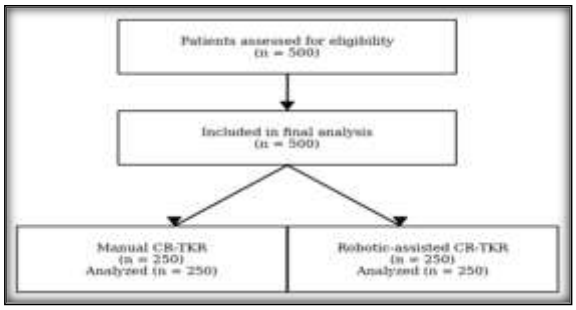

Figure 1: Study flow diagram

Interpretation: This figure summarizes patient inclusion and allocation into manual and robotic-assisted CR-TKR groups. It confirms the final sample size analyzed in each cohort.

RESULTS

Patient Characteristics

During the study period from October 2023 to December 2025, a total of 500 knees undergoing cruciate-retaining total knee replacement (CR-TKR) were enrolled for analysis. This cohort comprised 250 knees in the manual CR-TKR group and 250 knees in the robotic-assisted CR-TKR group.

Baseline demographic and clinical characteristics were comparable between the two groups. There were no statistically significant differences in age, sex distribution, body mass index (BMI), or preoperative range of motion (ROM) between the manual and robotic-assisted cohorts [Table 1].

Table 1: Demographics and Baseline Characteristics

Variable	Manual CR-TKR (n=250)	Robotic CR-TKR (n=250)	p value
Age (years), mean ± SD	66.2 ± 7.8	65.1 ± 8.0	0.46
Sex (M/F)	24 / 36*	22 / 38*	0.70
BMI (kg/m²), mean ± SD	28.4 ± 3.6	27.9 ± 3.4	0.42
Pre-op ROM (°), mean ± SD	101.3 ± 12.7	103.1 ± 12.1	0.41

Interpretation: Baseline demographics including age, sex distribution, BMI, and preoperative range of motion were comparable between the manual and robotic-assisted groups. No statistically significant differences were observed for any baseline variable. This suggests that both cohorts were well matched at the time of surgery. Therefore, subsequent differences in radiographic patellar height and functional outcomes are less likely to be influenced by baseline demographic imbalance.

Primary Outcome: Patellar Height (Blackburne–Peel Ratio): Postoperative radiographic assessment demonstrated that the robotic-assisted group had a significantly higher mean Blackburne-Peel (BP) ratio (0.66 ± 0.06) compared with the manual group (0.62 ± 0.07, p = 0.003) [Table 2].

Table 2: Primary Outcomes (BP Ratio and FJS-12)

Outcome	Manual CR-TKR (n=250)	Robotic CR-TKR (n=250)	p value
Blackburne–Peel ratio	0.62 ± 0.07	0.66 ± 0.06	0.003
Forgotten Joint Score-12	63.1 ± 12.8	71.4 ± 11.6	<0.001

Interpretation: The robotic-assisted group demonstrated a significantly higher mean Blackburne–Peel ratio compared to the manual group. This indicates improved restoration of patellar height in the robotic-assisted cohort. The robotic-assisted group also achieved significantly higher FJS-12 scores at follow-up. Overall, robotic-assisted CR-TKR showed better radiographic patellar height restoration and superior patient-reported joint awareness outcome compared with the manual technique.

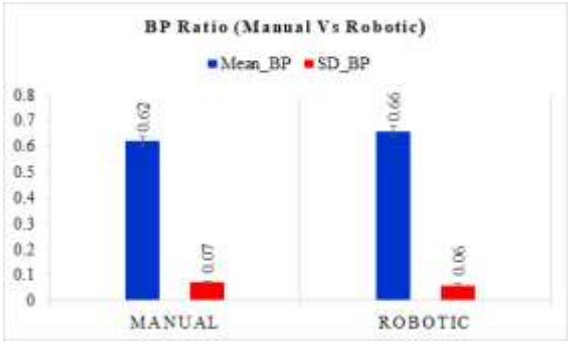

Figure 2: (BP Ratio box plot)

Interpretation: The robotic-assisted group shows a higher distribution of Blackburne–Peel ratio values compared with the manual group. This reflects improved postoperative patellar height restoration in the robotic-assisted cohort.

Secondary Outcome: Forgotten Joint Score-12 (FJS-12)

Functional outcome assessment using FJS-12 showed significantly higher scores in the robotic-assisted group (71.4 ± 11.6) compared with the manual group (63.1 ± 12.8, $p < 0.001$) [Table 2]. The Forgotten Joint Score is a validated patient-reported outcome measure for total knee arthroplasty, and minimal important difference values have been described.[13,15]

Patellar Height Category Distribution

Patients were stratified based on BP ratio into patella baja, normal patellar height, and patella alta categories. Patella baja was observed more frequently in the manual group compared with the robotic-assisted group (16.7% vs 6.7%, $p = 0.09$). Normal patellar height was more common in the robotic-assisted group (81.7% vs 70.0%, $p = 0.13$). Patella alta distribution was similar between groups (13.3% vs 11.7%, $p = 0.78$) [Table 3].

Table 3: Patellar Height Distribution (Baja/Normal/Alta)

Category (BP ratio)	Manual CR-TKR (n=250)	Robotic CR-TKR (n=250)	p value
Patella baja (<0.54)	16.7%	6.7%	0.09
Normal (0.54–0.73)	70.0%	81.7%	0.13
Patella alta (>0.73)	13.3%	11.7%	0.78

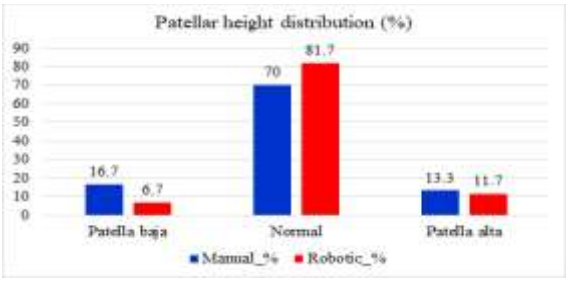

Figure 3: Patellar height distribution

Interpretation: Patella baja was observed more frequently in the manual group compared to the robotic-assisted group, although this difference did not reach statistical significance. Normal patellar height was more common in the robotic-assisted cohort. The proportion of patella alta was comparable between groups. These findings suggest a trend toward more physiological patellar height distribution after robotic-assisted CR-TKR.

Interpretation: Patella baja was more frequent in the manual group, while normal patellar height was more common in the robotic-assisted group. The proportion of patella alta was similar between the two cohorts.

FJS-12 by Patellar Height Category: When outcomes were analyzed within patellar height categories, knees classified as patella baja demonstrated lower FJS-12 scores compared with normal patellar height in both groups. In the manual group, mean FJS-12 was lowest in the patella baja subgroup (55.2 ± 10.6) compared with the normal subgroup (66.0 ± 11.5). In the robotic-assisted group, the normal-height subgroup demonstrated the highest FJS-12 (74.0 ± 10.3) [Table 4]. Joint line-related changes have been associated with inferior patient-reported outcomes in arthroplasty settings.[16]

Table 4: FJS-12 by Patellar Height Category

Patellar height group	Manual FJS-12	Robotic FJS-12	p value
Baja	55.2 ± 10.6	62.9 ± 9.8	0.04
Normal	66.0 ± 11.5	74.0 ± 10.3	<0.001
Alta	58.7 ± 13.4	66.5 ± 12.2	0.08

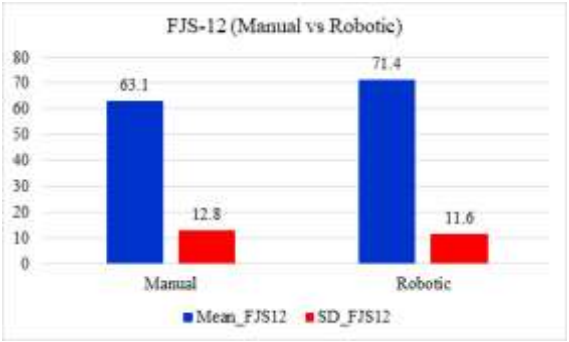

Figure 4: (FJS-12 box plot)

Interpretation: Within both groups, the patella baja subgroup demonstrated lower FJS-12 scores compared with knees having normal patellar height. The robotic-assisted group showed higher FJS-12 scores across all patellar height categories. The largest difference between techniques was observed in the normal-height subgroup, where robotic-assisted CR-TKR achieved the highest joint awareness scores. This subgroup analysis supports the relationship between patellar height status and functional outcome.

Interpretation: FJS-12 values are higher in the robotic-assisted group compared with the manual group, indicating reduced joint awareness after surgery. The plot also demonstrates variability in functional outcomes within each cohort.

Correlation Between BP Ratio and FJS-12

Correlation analysis demonstrated a moderate positive relationship between BP ratio and FJS-12 (overall $r = 0.34$, $p < 0.001$). Group-wise analysis also remained positive (manual: $r = 0.29$, $p = 0.02$; robotic: $r = 0.37$, $p = 0.004$) [Table 5]. Prior reports have shown that improvements in surgical precision do not uniformly translate to differences in FJS-12 across all cohorts.[14]

Table 5: Correlation analysis (BP vs FJS)

Relationship	r value	p value
BP ratio vs FJS-12 (overall)	+0.34	<0.001
BP ratio vs FJS-12 (manual)	+0.29	0.02
BP ratio vs FJS-12 (robotic)	+0.37	0.004

Interpretation: A moderate positive correlation was observed between BP ratio and FJS-12 in the overall cohort. Group-wise correlations were also positive in both manual and robotic-assisted cohorts. This indicates that higher postoperative patellar height (higher BP ratio) is associated with better patient-reported joint awareness outcomes. The consistent correlation across both techniques supports the relevance of patellar height restoration in CR-TKR outcomes.

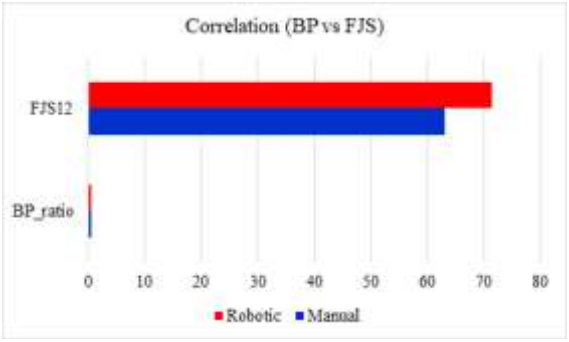

Figure 5: (Scatter BP vs FJS correlation)

Interpretation: A positive relationship is observed between BP ratio and FJS-12, with higher BP ratios associated with higher FJS-12 scores. This supports the correlation findings reported in [Table 5].

Follow-up and Attrition

The average duration of postoperative follow-up was 14 months. During the follow-up period, 18 patients were lost to follow-up and were excluded from the final analysis.

DISCUSSION

The principal finding of the present study is that postoperative patellar height differed significantly between robotic-assisted and manual cruciate-retaining total knee replacement, with the robotic-assisted cohort demonstrating a higher mean Blackburne–Peel (BP) ratio. In parallel, patients in the robotic-assisted group reported significantly higher Forgotten Joint Score-12 (FJS-12) values, indicating improved patient-perceived joint awareness. Furthermore, a moderate positive correlation was observed between BP ratio and FJS-12 across the overall cohort, supporting the hypothesis that patellar height restoration is associated with functional outcomes following CR-TKR.

Patellofemoral biomechanics are a critical determinant of postoperative function following knee arthroplasty. Alterations in patellar height can influence extensor mechanism efficiency, patellofemoral contact patterns, and tracking behavior during knee flexion. Joint line elevation and extensor mechanism imbalance have been associated with inferior patient-reported outcomes in contemporary arthroplasty cohorts, reinforcing the importance of restoring anatomical relationships during surgery.[17] In the present study, subgroup analysis demonstrated lower FJS-12 scores in knees classified as patella baja compared with those having normal patellar height, in both manual and robotic-assisted groups. These findings suggest that deviation from physiological patellar height may negatively impact patient-perceived joint integration, irrespective of surgical technique.

Robotic-assisted total knee arthroplasty has been proposed as a means of improving surgical precision by enhancing accuracy in bone resection, component positioning, and soft-tissue balancing. However, the relationship between technical accuracy and patient satisfaction remains complex. Systematic review evidence indicates that robotic-assisted TKA is not uniformly associated with superior patient satisfaction or functional outcomes compared with conventional manual techniques.[18] Within this context, the improved FJS-12 observed in the robotic-assisted cohort of the present study may reflect more consistent restoration of patellar height and patellofemoral biomechanics, rather than robotic assistance alone. This interpretation is supported by the observed association between BP ratio and FJS-12, highlighting patellar height as a potentially important mediator between surgical technique and patient-reported outcomes.

Rotational alignment and rotational mismatch have also been identified as important contributors to patellofemoral kinematics and overall knee function following arthroplasty. Variability in femoral and tibial component rotation has been reported even within accepted tolerance ranges, emphasizing the challenge of achieving consistent rotational alignment using conventional instrumentation.[17] Robotic assistance has been shown to reduce rotational mismatch in some studies; however, improvements in rotational accuracy do not consistently translate into higher FJS-12 scores across all cohorts.[15] The present findings suggest that patellar height restoration may represent a more directly relevant and measurable factor influencing joint awareness, complementing other technical considerations such as rotational alignment.

In addition to clinical outcomes, robotic-assisted arthroplasty carries practical considerations including operative time, learning curve, and cost. Previous studies have demonstrated a learning curve associated with robotic-assisted TKA, with increased operative time during early adoption that improves with surgical experience.[21] From a health-economic perspective, cost-effectiveness analyses suggest that

robotic-assisted TKA may be economically viable under certain assumptions related to surgical volume, reduction in revision rates, and quality-adjusted life years; however, cost-effectiveness remains highly dependent on institutional and healthcare system factors[19,20]. These considerations are particularly relevant for centres adopting robotic-assisted CR-TKR with the goal of improving consistency and reproducibility of surgical outcomes rather than guaranteeing improvements in patient satisfaction alone.

Limitations

This study has several limitations. First, although patellar height was assessed radiographically using the BP ratio and functional outcome was evaluated using the FJS-12, direct assessment of patellofemoral contact forces or dynamic kinematics was not performed. Second, as a single-centre study, the findings may reflect institution-specific surgical techniques and patient characteristics, which may limit generalizability. Third, although the average follow-up duration was 14 months, longer-term follow-up is required to determine whether differences in patellar height restoration result in sustained functional benefits over time.

Clinical Implications

The findings of this study suggest that restoration of physiological patellar height should be considered an important surgical objective in cruciate-retaining total knee replacement. Robotic assistance may reduce variability and improve consistency in achieving desired patellar height parameters; however, patient satisfaction and joint awareness remain multifactorial outcomes, influenced by component alignment, soft-tissue balance, and patient-specific factors (18). Attention to patellofemoral mechanics, particularly patellar height, may therefore enhance functional outcomes irrespective of the surgical technique employed.

CONCLUSION

Postoperative patellar height demonstrated a significant association with patient-reported joint awareness following cruciate-retaining total knee replacement. In this study, robotic-assisted CR-TKR achieved more consistent restoration of patellar height, as reflected by a higher mean Blackburne–Peel ratio, and was associated with higher Forgotten Joint Score-12 values compared with manual CR-TKR. Subgroup analysis showed that patella baja was associated with inferior functional outcomes, underscoring the clinical importance of maintaining physiological patellar height during surgery.

The observed positive correlation between the Blackburne–Peel ratio and Forgotten Joint Score-12 support patellar height restoration as a relevant and measurable factor influencing postoperative joint awareness. These findings suggest that optimization of patellar height and extensor mechanism mechanics may contribute to improved functional integration after CR-TKR. While robotic assistance may help reduce variability in patellar height restoration, patient-reported outcomes remain multifactorial and influenced by multiple surgical and patient-specific factors.

Further multicentre studies with larger cohorts, longer follow-up durations, and objective assessment of patellofemoral biomechanics are required to confirm these findings and to better define the role of patellar height restoration in improving outcomes after cruciate-retaining total knee replacement.

REFERENCES

1. Tischer T, Geier A, Lutter C, Enz A, Bader R, Kebbach M. Patella height influences patellofemoral contact and kinematics following cruciate-retaining total knee replacement. Journal of Orthopaedic Research®. 2023 Apr;41(4):793-802.
2. Han H, Zhang X. A new method for evaluation of patellar height and the position of the joint line before and after total knee arthroplasty. BMC musculoskeletal disorders. 2020 Nov 21;21(1):768.
3. Dos-Santos G, Gutierres M, Leite MJ, Barros AS. Pseudo-patella baja after total knee arthroplasty: radiological evaluation and clinical repercussion. The Knee. 2021 Dec 1; 33:334-41.
4. Suthar A, Yukata K, Azuma Y, Suetomi Y, Yamazaki K, Seki K, Sakai T, Fujii H. Significant reduction of patellar height affected lower clinical outcomes and knee flexion over five-year follow-up after total knee arthroplasty. Bone & Joint Open. 2021 Dec 17;2(12):1075-81.
5. Ekinci M, Şentürk F, Şahin K, Karalar Ş, Sağlam Y, Şen C. JOINT LINE CHANGES AND PATELLA BAJA INFLUENCE CLINICAL OUTCOMES OF REVISION TOTAL KNEE ARTHROPLASTY. Journal of Istanbul Faculty of Medicine. 2024 Apr 1;87(2):113-20.
6. Lachowski K, Prill R, Salzmann M, Becker R. Inferior patellar mobility before and after knee arthroplasty: A comparison with healthy knees. Knee Surgery, Sports Traumatology, Arthroscopy. 2024 Jun;32(6):1531-8.
7. Holtz N, Hamilton DF, Giesinger JM, Jost B, Giesinger K. Minimal important differences for the WOMAC osteoarthritis index and the Forgotten Joint Score-12 in total knee arthroplasty patients. BMC musculoskeletal disorders. 2020 Jun 23;21(1):401.
8. Adamska O, Modzelewski K, Szymczak J, Świderek J, Maciąg B, Czuchaj P, Poniatowska M, Wnuk A. Robotic-assisted total knee arthroplasty utilizing NAVIO, CORI imageless systems and manual TKA accurately restore femoral rotational alignment and yield satisfactory clinical outcomes: a randomized controlled trial. Medicina. 2023 Jan 27;59(2):236.
9. Xu J, Li L, Fu J, Xu C, Ni M, Chai W, Hao L, Zhang G, Chen J. Early clinical and radiographic outcomes of robot-assisted versus conventional manual total knee arthroplasty: a randomized controlled study. Orthopaedic Surgery. 2022 Sep;14(9):1972-80.
10. Alrajeb R, Zarti M, Shuia Z, Alzobi O, Ahmed G, Elmhiregh A. Robotic-assisted versus conventional total knee arthroplasty: a systematic review and meta-analysis of randomized controlled trials. European Journal of Orthopaedic Surgery & Traumatology. 2024 Apr;34(3):1333-43.
11. Daoub A, Qayum K, Patel R, Selim A, Banerjee R. Robotic assisted versus conventional total knee arthroplasty: a systematic review and meta-analysis of randomised controlled trials. Journal of Robotic Surgery. 2024 Oct 9;18(1):364.
12. Bensa A, Sangiorgio A, Deabate L, Illuminati A, Pompa B, Filardo G. Robotic-assisted mechanically aligned total knee arthroplasty does not lead to better clinical and radiological outcomes when compared to conventional TKA: a systematic review and meta-analysis of randomized controlled trials.

Knee surgery, sports traumatology, arthroscopy. 2023 Nov;31(11):4680-91.
13. Pansky A, Bar-Ziv Y, Tamir E, Finestone A, Agar G, Shohat N. Reliability and validity of the Hebrew version of the Forgotten Joint Score for assessing the outcomes of total knee arthroplasty. Arthroplasty. 2021 Aug 3;3(1):27.
14. Yamamoto A, Kaneko T, Takada K, Yoshizawa S. Robotic-assisted total knee arthroplasty improves the rotational mismatch between femoral and tibial components, but not the forgotten joint score 12: a single-center retrospective cohort study. Journal of Experimental Orthopaedics. 2023 Dec 8;10(1):133.
15. Holtz N, Hamilton DF, Giesinger JM, Jost B, Giesinger K. Minimal important differences for the WOMAC osteoarthritis index and the Forgotten Joint Score-12 in total knee arthroplasty patients. BMC musculoskeletal disorders. 2020 Jun 23;21(1):401.
16. Buller LT, Metzger CM, Deckard ER, Meneghini RM. The effect of joint line elevation on patient-reported outcomes after contemporary revision total knee arthroplasty. The Journal of Arthroplasty. 2022 Jun 1;37(6):1146-52.
17. Nedopil AJ, Howell SM, Rudert M, Roth J, Hull ML. How frequent is rotational mismatch within 0°±10° in kinematically aligned total knee arthroplasty? Orthopedics. 2013 Dec 1;36(12): e1515-20.
18. Hoveidaei AH, Esmaeili S, Ghaseminejad-Raeini A, Pirahesh K, Fallahi MS, Sandiford NA, Citak M. Robotic assisted total knee arthroplasty (TKA) is not associated with increased patient satisfaction: a systematic review and meta-analysis. International orthopaedics. 2024 Jul;48(7):1771-84.
19. Hua Y, Salcedo J. Cost-effectiveness analysis of robotic-arm assisted total knee arthroplasty. PLoS One. 2022 Nov 28;17(11):e0277980.
20. Zhang JJ, Chen JY, Tay DK, Pang HN, Yeo SJ, Liow MH. Cost-effectiveness of robot-assisted total knee arthroplasty: a markov decision analysis. The Journal of Arthroplasty. 2023 Aug 1;38(8):1434-7.
21. Tay ML, Carter M, Zeng N, Walker ML, Young SW. Robotic-arm assisted total knee arthroplasty has a learning curve of 16 cases and increased operative time of 12 min. ANZ Journal of Surgery. 2022 Nov;92(11):2974-9.