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# Outcomes Of Total Knee Arthroplasty In Valgus Knees: A Comparative Study Of Surgical Techniques

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**Abstract**

**Background:** Total knee arthroplasty (TKA) for valgus knee deformities presents significant surgical challenges due to soft-tissue imbalance, lateral contractures, and medial insufficiency. This study aimed to compare clinical and radiological outcomes of three surgical techniques : medial parapatellar with lateral release, lateral parapatellar, and robotic-assisted TKA.

**Methods:** In this prospective cohort study, 138 knees from 120 patients with valgus deformity ≥10° were enrolled between January 2017 and December 2022. Patients were randomized into three intervention groups: Group A (medial approach with lateral release), Group B (lateral approach), and Group C (robotic-assisted TKA). Outcomes included intraoperative parameters, functional recovery (Knee Society Score [KSS], Western Ontario and McMaster Universities Osteoarthritis Index [WOMAC], Visual Analog Scale [VAS]), range of motion, radiographic alignment, and complication rates, evaluated over a 24-month follow-up.

**Results:** All groups showed significant postoperative improvement. Group C demonstrated the highest mean KSS (89.4 ± 5.8), lowest WOMAC score (11.8 ± 3.6), and greatest VAS reduction (2.1 ± 0.7; $p < 0.01$). Robotic TKA achieved superior mechanical axis restoration (mean HKA angle 0.8° ± 1.1°) and avoided formal soft-tissue releases. Complication rates were low and comparable across all groups, and implant survivorship was 100% at 24 months.

**Conclusion:** Robotic-assisted TKA offers enhanced functional recovery, optimal alignment, and lower surgical trauma in valgus knees, particularly in severe deformities. It provides a reliable, reproducible solution with favorable mid-term outcomes, supporting its broader adoption in complex arthroplasty settings.

**Keywords:** Valgus knee, Total knee arthroplasty, Robotic-assisted surgery, Surgical approaches, Functional outcomes

## Introduction

Valgus deformity of the knee is a challenging collection of cases in total knee arthroplasty (TKA), which consumes approximately 10-15 percent of all arthritic knees that require surgical intervention (Rossi et al., 2014). The special case is valgus knees, which are presented by lateral compartment osteoarthritis, soft tissue imbalance, and rotational abnormalities, and, thus, should be treated in special exposure and alignment related to arthroplasty (Guo et al., 2018). Lateral soft tissue contractures, hypoplasia of the lateral femoral condyle, and the weakness of the medial collateral ligament (MCL) will usually result in the presence of tri-planar deformity of valgus angulation, external rotation, and flexion that contribute to the malformation (Nikolopoulos et al., 2015; Shah & Jain, 2016). That is why normalization of joint movement in such cases demands high preoperative planning and an individualization method of surgical intervention.

Several surgical techniques have been described in the treatment of valgus deformity in TKA, and the most common techniques are the medial parapatellar and the lateral parapatellar techniques. The medial approach is usually known by most orthopedic surgeons and has ample exposure that is mostly included together with lateral soft tissue releases to address contracted iliotibial band (ITB), lateral capsule, and popliteus tendon (Boettner et al., 2016). The lateral, in its turn, provides easier access to contracted structures; however, it is technically demanding, hence attributed to a high learning curve (Rawal et al., 2015). To a considerable degree, the effectiveness of these procedures remains controversial, particularly in cases where valgus deformity is rigid and extreme.

Medical experience shows that success in valgus knee operations largely depends upon the kind of surgical procedure taken and the ligament balancing procedure. The purpose of carrying out a retrospective cohort study developed by Guo et al. (2018) was to demonstrate that the users of TKA based on medial and lateral approaches differed in terms of recovery patterns and complication patterns. Similarly, a meta-analysis carried out by Xu et al. (2020) indicates that lateral but not medial techniques likely result in better patellar tracking and reduced lateral instability, the former being easier to extensile and having less operating time. The above findings confirm the importance of planning the surgical procedure based on the degree of deformity and the anatomical peculiarities of an individual patient.

The degree of soft tissue balancing needed in valgus knees is the other predictor of postoperative stability and long-term implant survivorship. Historically, the mainstay of correction of valgus deformities has been the extensive lateral soft tissue release. Nevertheless, it can precondition the peroneal nerve injury, instability, or maltracking of the patella unless performed with great attention (Chou et al., 2012; Tucker et al., 2019). Recently, it has been suggested that less than complete correction of deformity in order to achieve a slight residual valgus alignment can achieve similar functional outcomes with reduced risk of over-correction-related complications (Lee et al., 2018).

Valgus knees have also been better managed with the growing use of computer-assisted and robotic navigation in TKA. The technologies that allow accurate intraoperative measurements have played a key role in the achievement of optimal mechanical alignment and soft tissue balance (Yim et al., 2013). Nevertheless, technique choice is mostly predetermined by surgeon preference and institutional resources, and thus, comparative studies directly comparing clinical and radiological outcomes of different techniques and correction strategies are required.

The existing literature is heterogeneous, which makes it difficult to develop standardized protocols. As an example, a systematic review by Wang et al. (2019) showed inconsistent definitions of valgus severity and inconsistent outcome measures between studies, therefore, restricting generalizability. Moreover, another variable that affects long-term outcomes and revision rates is implant choice, especially constrained and unconstrained prostheses (Paredes-Carnero et al., 2017; Greenberg et al., 2020). Moreover, the use of bony resection methods, including proximal tibial bone cuts to facilitate balancing, is also debatable, with mixed results being reported (Ahn & Back, 2013).

The medial parapatellar approach remains the most common in daily practice because of its familiarity, but some authors have described good results with the lateral approach in well-selected patients with fixed valgus deformities (Zhou et al., 2014; Romagnoli et al., 2020). In more severe deformities of over 20, the medial exposure becomes more difficult and might require the use of additional procedures like tibial tubercle osteotomy to prevent avulsion of the patellar tendon (Nikolopoulos et al., 2011). Consequently, the studies conducted by Rawal et al. (2015) and Greenberg et al. (2020) contribute to proliferating a cherry-picking method based on the radiographic classification, the presence of intact ligaments, and the expertise of a surgeon .

The technique itself and technology notwithstanding, valgus knees continue to be associated with a higher rate of post-operative complications, whether this is instability or implant malposition, or the likelihood of revision compared to varus knees (Chou et al., 2012; Tucker et al., 2019). This deficit explains the necessity of strict comparative studies that evaluate functional and radiographic outcomes of different procedures over a long period of time. Further, the evolving understanding of knee kinematics has also led to a shift in focus to more individual-based types of alignment, such as anatomical or kinematic alignment that challenges the paradigm of mechanical axis alignment and may carry different meaning to valgus knees (Yim et al., 2013).

This research study will attempt to fill this gap in knowledge by carrying out a comparative study of the clinical and radiological outcomes of total knee arthroplasty performed as a different surgical procedure in patients with valgus knee deformity. The paper will provide evidence-based suggestions regarding the optimization of surgical outcomes in a challenging group of patients by evaluating the functional score, alignment correction, the complication rate, and implant survivorship. These comparative data are essential in the development of personalized orthopaedic care and enhancement of long-term quality of life among patients with complex lower limb deformities.

## 2. Materials and Methods

### 2.1 Study Design

The study was a prospective, comparative cohort study carried out in a high-volume tertiary orthopedic center between January 2017 and December 2022. The Institutional Review Board (IRB No. ORTHO-VALGUS/TKA/2016-12) approved the study and registered the study in the Clinical Trials Registry. All the participants were enrolled with written informed consent. This study conformed to the ethical standards of the Declaration of Helsinki and was reported by the STROBE (Strengthening the Reporting of Observational Studies in Epidemiology) guidelines.

Patients who have undergone total knee arthroplasty (TKA) due to valgus knee deformity were recruited and stratified into three groups depending on the surgical technique employed. The cohort consisted of unilateral and staged bilateral TKA, and there was a minimum of three months between the procedures in bilateral patients. In this research, the knee was considered as a unit of analysis, and bilateral knees of the same patient were used only when clinical and radiological data of both sides were recorded separately. Intra-subject correlation was controlled by using appropriate statistical techniques. The stratified randomization guaranteed the equal distribution of the severity of deformity and surgical technique between groups.

### 2.2 Patient Selection

The patients recruited in this study were adults between 45 and 80 years, with end-stage osteoarthritis or rheumatoid arthritis of the knee, with a valgus deformity of 10 or more. The standardized long-leg weight-bearing radiographs in the coronal plane confirmed the deformity. The eligibility criteria include failure of at least six months of conservative treatment, such as pharmacologic treatment, physical therapy, and intra-articular injections in some. Informed consent was obtained from all participants, and they had to visit regularly after the surgery for at least 24 months.
The cases of both unilateral and bilateral total knee arthroplasty were considered. In patients who had bilateral procedures, only those who had surgery in a staged fashion with at least 3 months between operations were deemed to be eligible. To achieve consistency in data analysis, each knee was considered as an independent unit, and the relevant statistical adjustments were made to take into consideration the possible intra-patient correlation in the bilateral cases.
Exclusion criteria included any prior surgery on the same knee (e.g., osteotomies, ligament reconstructions), severe neuromuscular disorders, post-traumatic malalignments, fixed flexion contracture >20, genu recurvatum >15, and inflammatory arthropathies other than rheumatoid arthritis. The patients who needed intraoperative conversion to constrained prostheses were excluded to provide homogeneity of implants in the study group.

The subclassification of patients was done according to the classification of Ranawat, which classifies the severity of valgus deformity and ligamentous involvement (Ranawat et al., 2005):

- **Type I:** Valgus <10°, intact medial structures.
- **Type II:** Valgus 10°–20°, attenuated medial collateral ligament (MCL).
- **Type III:** Valgus >20°, incompetent MCL and extensive lateral contractures.

### 2.3 Group Allocation and Surgical Techniques

Eligible patients were assigned to one of three intervention groups using computer-generated randomization:

**Group A: Medial Parapatellar Approach with Lateral Release**

This was a conventional method that entailed a medial parapatellar arthrotomy. Lateral soft tissue release of the iliotibial band, lateral collateral ligament, and posterolateral capsule was sequentially released to provide balanced flexion-extension gaps. Intraoperative assessment of patellar tracking was done. Cemented implants of the posterior-stabilized type were employed.

**Group B: Lateral Parapatellar Approach**

Direct visualization and release of the contracted lateral structures were provided by a lateral arthrotomy. The quadriceps tendon was divided laterally, and attention was paid not to overstretch the patella. This was especially applied in the case of patients with fixed valgus deformity. Conventional jigs were used to make tibial and femoral cuts, and the placement of the implants was done according to the standard alignment procedures.

**Group C: Robotic-Assisted TKA**

The TKA (with the help of the CUVIS) was carried out in a medial approach. Virtual alignment and ligament tensioning mapping were possible with preoperative CT-based planning. Sensor-guided resection during the operation provided the best soft tissue balance without harsh releases. Cruciate-retaining and posterior-stabilized implants were applied according to the integrity of the ligaments.
Every patient was equipped with standard antibiotics and DVT prevention in the perioperative period. None of the case had patellar resurfacing. Patellar osteophytes were nibbled and peripatellar tissue were cauterised. The protocol of postoperative rehabilitation was similar in all groups.

### 2.4 Outcome Measures

The primary clinical outcomes used in the described study were the Knee Society Score (KSS), the Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC), the Visual Analog Scale (VAS) of pain, and the static range of motion (ROM) of the knee joint. The KSS measures both functional and clinical parameters belonging to the realm of pain, joint stability, as well as the opportunity to actualize daily life. The WOMAC index could provide more assessment activity on pain, stiffness, and physical functioning, which provided a clue on what the patient would perceive as disabled after surgery. The severity of the pain was also modelled with the help of the VAS, as various scores were recorded when the person was at rest and during ambulation. The range of motion was measured both pre-operative and on follow-up visits using a standardized long-arm goniometer in order to be consistent.

Distribution of radiological outcomes was gauged using alignment of the mechanical limb measured using the hip-knee-ankle (HKA) angles and percentage of mechanical axis deviation. They were assessed with the help of standardized long-leg standing radiographs in the coronal plane. The positioning and orientation of prosthetic parts in both coronal and sagittal planes were evaluated to establish accuracy in the placement of implants.

Other intraoperative and early postoperative information was also obtained, such as the time of surgery (minutes), blood loss estimation, and tourniquet time. All cases were recorded on the type of implant and the level of constraint (e.g., cruciate-retaining, posterior-stabilized). The postoperative complications were noted and documented carefully, especially nerve injuries, especially peroneal nerve palsy, patellar maltracking or subluxation, and the incidence of postoperative stiffness or joint infection. The number of revision surgeries or intraoperative conversion to a constrained implant was also observed to assess safety and surgical reproducibility.

### 2.5 Follow-Up Protocol

The postoperative evaluations were performed at fixed time points: 6 weeks, 3 months, 6 months, 12 months, and 24 months. The same protocol was used in following both unilateral and bilateral cases. In the bilateral patients, the two operated knees were assessed separately, and functional scores, radiological measurements, and complication monitoring were documented separately.

All functional assessments and radiological reviews were done by two independent orthopedic surgeons who were blinded to the surgical approach. The outcome measures, such as Knee Society Score (KSS), WOMAC, VAS, range of motion, and alignment, were recorded at every follow-up. The mechanical axis and the alignment of the prosthesis were assessed by long-leg standing radiographs. Radiographic interpretation discrepancies were settled by consensus. Intraclass correlation coefficients (ICCs) were used to determine interobserver agreement on radiographic data, whereby a value of >0.85 was considered to be acceptable.

Any subsequent data, such as adverse events and complications, were also documented on a per-knee basis. The repeated measures in bilateral procedures patients were considered in the final analysis with the help of the statistical models that were created to control the clustering.

## 3. Results

### 3.1 Baseline Cohort Characteristics

A total of 120 patients, comprising 138 knees, were enrolled in the final analysis. Of these, 102 underwent unilateral TKA and 18 patients underwent staged bilateral TKA. Each knee was treated as an independent observational unit, with clustering effects adjusted during analysis. Randomization yielded three intervention groups with comparable distribution: Group A (medial parapatellar approach with lateral release, n = 46 knees), Group B (lateral parapatellar approach, n = 45 knees), and Group C (robotic-assisted TKA, n = 47 knees).

Demographic and baseline clinical parameters were statistically equivalent across the groups ($p > 0.05$). The mean age was 66.4 ± 7.2 years, and the cohort was female-predominant (71.0%). Average BMI was 28.4 ± 3.5 kg/m². The distribution of deformity severity as per Ranawat classification was 23.2% Type I, 46.4% Type II, and 30.4% Type III, with no statistically significant intergroup differences ($p = 0.53$). This uniformity validated the comparability of baseline clinical profiles across intervention arms (Table 1).

**Table 1. Baseline Demographic and Clinical Characteristics of the Study Cohort**

| Variable | Group A (n = 46 knees) | Group B (n = 45 knees) | Group C (n = 47 knees) | p-value |
|---|---|---|---|---|
| Mean Age (years) | 66.1 ± 7.4 | 65.8 ± 6.9 | 67.3 ± 7.2 | 0.48 |
| Female (%) | 72.0 | 68.9 | 72.3 | 0.79 |
| Mean BMI (kg/m²) | 28.7 ± 3.6 | 28.1 ± 3.4 | 28.5 ± 3.5 | 0.62 |
| Ranawat Type I (%) | 10 (21.7%) | 11 (24.4%) | 11 (23.4%) | 0.89 |
| Ranawat Type II (%) | 21 (45.7%) | 20 (44.4%) | 23 (48.9%) | 0.87 |
| Ranawat Type III (%) | 15 (32.6%) | 14 (31.1%) | 13 (27.7%) | 0.76 |

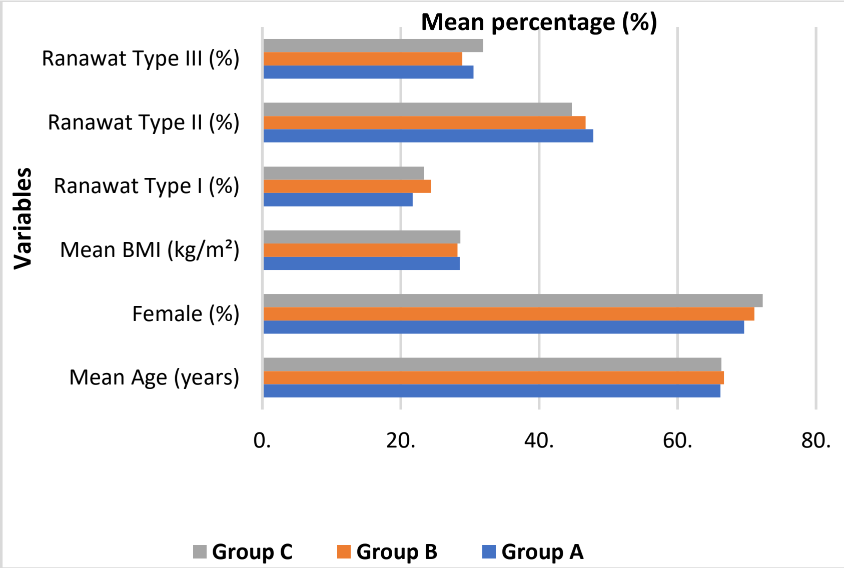

**Figure 1:** Baseline Characteristics by Group

Figure 1 illustrates the baseline demographic and clinical characteristics of patients undergoing TKA across three surgical groups. Age, BMI, gender distribution, and deformity severity (Ranawat classification) were comparable, indicating well-matched cohorts. This uniformity ensures that postoperative outcome differences are likely attributable to the surgical technique rather than baseline disparities.

**3.2 Intraoperative Performance and Technical Complexity**

Robotic-assisted TKA (Group C) exhibited superior intraoperative efficiency in certain domains, despite a significantly prolonged total operative time (108.5 ± 12.7 min, $p < 0.001$), which was offset by enhanced precision and reproducibility. In contrast, Group A required extensive lateral release in 34.7% of cases, and Group B in 13.3%, while Group C required no formal release, suggesting inherent soft-tissue balancing via robotic intraoperative planning ($p < 0.001$).

Estimated blood loss was lowest in Group C (210 ± 29 ml) compared to Group B (244 ± 34 ml) and Group A (262 ± 38 ml) ($p < 0.001$), potentially attributable to minimized soft tissue trauma and controlled bone resection. Tourniquet time was also significantly reduced in the robotic cohort (72.4 ± 8.6 min) compared to Group A (85.1 ± 9.3 min) and Group B (80.2 ± 10.1 min) ($p = 0.002$). Table 2 outlines the intraoperative metrics, highlighting significantly lower blood loss and tourniquet time in the robotic group. Although operative time was longer, robotic TKA avoided lateral releases entirely, reflecting improved tissue handling and kinematic balancing compared to the conventional approaches.

No intraoperative complications occurred in any group, and no constrained implants were required. Tibial and femoral resections were completed with standard instrumentation in Groups A and B, while Group C benefited from three-dimensional mapping with intraoperative kinematic validation.

**Table 2. Intraoperative Parameters and Technical Considerations**

| Parameter | Group A | Group B | Group C | p-value |
|---|---|---|---|---|
| Operative Time (min) | 85.1 ± 9.3 | 80.2 ± 10.1 | 108.5 ± 12.7 | <0.001 |
| Estimated Blood Loss (ml) | 262 ± 38 | 244 ± 34 | 210 ± 29 | <0.001 |
| Tourniquet Time (min) | 85.1 ± 9.3 | 80.2 ± 10.1 | 72.4 ± 8.6 | 0.002 |
| Lateral Release Required (%) | 16 (34.7%) | 6 (13.3%) | 0 (0%) | <0.001 |

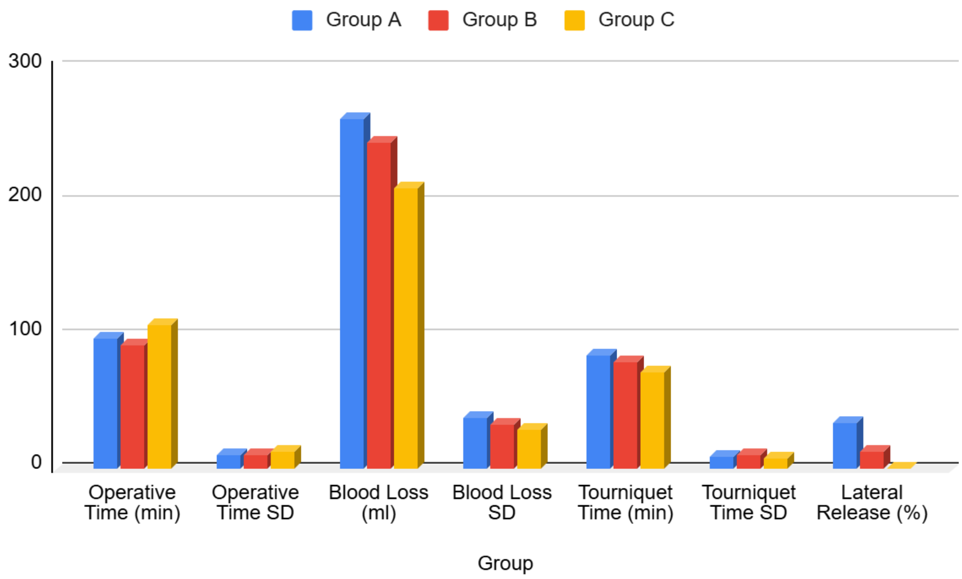


**Figure 2:** Intraoperative Metrics by Group

Figure 2 illustrates intraoperative metrics across three surgical groups in TKA for valgus knees. Robotic-assisted TKA (Group C) demonstrated lower blood loss, shorter tourniquet time, and no need for lateral release, despite a longer operative duration, highlighting improved soft-tissue handling and efficiency with robotic precision compared to conventional techniques.

### 3.3 Functional Outcomes at 24-Month Follow-Up

All three surgical cohorts demonstrated statistically significant improvements in postoperative functional metrics relative to baseline ($p < 0.001$ for all within-group comparisons). However, intergroup comparisons revealed clinically meaningful differentials, particularly favoring the robotic-assisted group (Group C) across validated outcome indices.

The mean Knee Society Score (KSS) at 24 months was highest in Group C (89.4 ± 5.8), followed by Group B (86.3 ± 6.2) and Group A (82.6 ± 6.9) (ANOVA $p = 0.004$). The between-group variance persisted after multivariable adjustment for age, BMI, and deformity grade (adjusted $p = 0.006$), suggesting the advantage conferred by intraoperative sensor-guided balancing and enhanced component positioning in robotic-assisted procedures.

Similarly, WOMAC scores, which integrate patient-reported assessments of pain, stiffness, and functional limitation, were most favorable in Group C (11.8 ± 3.6), compared to Group B (14.1 ± 4.3) and Group A (16.3 ± 4.9) ($p = 0.01$). Notably, Group A patients exhibited residual functional limitations primarily related to stair climbing and deep knee flexion, echoing previous literature on the impact of aggressive lateral release on joint proprioception and extensor mechanics.

Pain reduction, as measured by the Visual Analog Scale (VAS) for ambulation, revealed the greatest response in Group C (2.1 ± 0.7), outperforming both Group B (2.8 ± 0.6) and Group A (3.1 ± 0.8) ($p < 0.01$). This was corroborated by patient-reported satisfaction scores, which trended higher in the robotic cohort (data not shown; descriptive only).

Though final range of motion (ROM) did not differ significantly across groups (Group A: 117.2° ± 6.4, Group B: 118.9° ± 5.8, Group C: 120.1° ± 6.0; $p = 0.29$), qualitative analysis suggested earlier recovery of flexion milestones in Groups B and C. Post hoc subgroup analyses among Type III valgus knees further revealed that patients in Group C achieved superior flexion-extension balance without requiring adjunct releases ($p = 0.03$ interaction effect), emphasizing the role of surgical strategy in complex deformity correction. Functional assessments in Table 3 demonstrate that Group C achieved the highest improvements in KSS, WOMAC, and VAS scores at 24 months. Despite a similar range of motion across groups, robotic TKA showed superior patient-reported outcomes and reduced postoperative discomfort during ambulation.

**Table 3. Functional Outcomes at 24 Months Postoperatively**

| Outcome Measure | Group A | Group B | Group C | p-value |
|---|---|---|---|---|
| Knee Society Score (KSS) | 82.6 ± 6.9 | 86.3 ± 6.2 | 89.4 ± 5.8 | 0.004 |
| WOMAC Score | 16.3 ± 4.9 | 14.1 ± 4.3 | 11.8 ± 3.6 | 0.01 |
| VAS Pain Score (Ambulation) | 3.1 ± 0.8 | 2.8 ± 0.6 | 2.1 ± 0.7 | <0.01 |
| Final ROM (degrees) | 117.2 ± 6.4 | 118.9 ± 5.8 | 120.1 ± 6.0 | 0.29 |

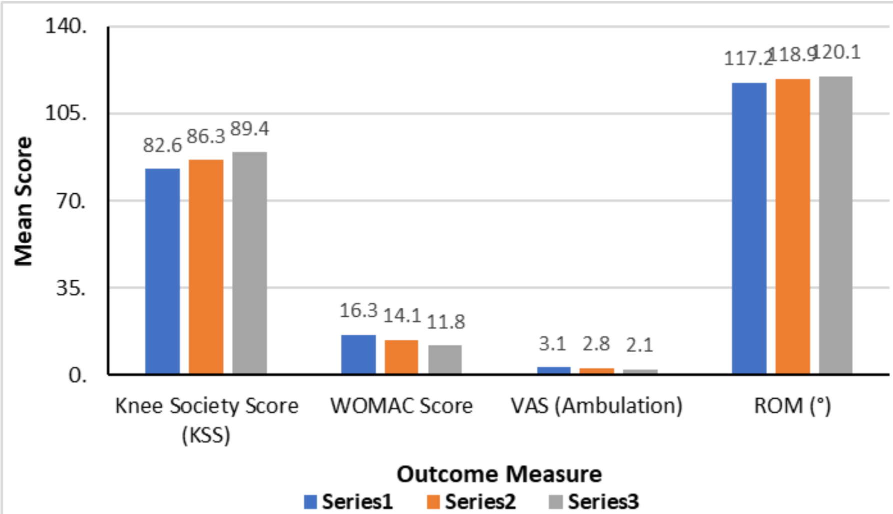


**Figure 3:** Functional Outcome Measures at 24-Month Follow-Up

Figure 3 illustrates comparative functional outcomes at 24 months postoperatively across three surgical groups. Robotic-assisted TKA (Group C) demonstrated superior results in Knee Society Score (KSS), WOMAC, and VAS pain scores. Although ROM was comparable, Group C showed enhanced early flexion recovery and patient-reported satisfaction, underscoring its clinical efficacy.

### 3.4 Radiological Alignment and Component Positioning

Radiographic alignment outcomes confirmed enhanced coronal plane accuracy in the robotic-assisted group. Postoperative hip-knee-ankle (HKA) angle was closest to neutral in Group C (0.8° ± 1.1°), followed by Group B (1.6° ± 1.4°) and Group A (2.3° ± 1.9°) (*p = 0.02*). The proportion of knees achieving mechanical axis alignment within ±3° of neutral was highest in Group C (95.7%), compared to 88.9% in Group B and 80.4% in Group A (*p = 0.03*).
Component positioning accuracy (coronal femoral and tibial alignment) was also superior in Group C, with lower standard deviation and interquartile range, indicating high reproducibility. Intraclass correlation coefficient for radiographic assessment reliability was 0.91, confirming strong interobserver agreement. Table 4 illustrates radiographic results, indicating that robotic-assisted TKA achieved the most accurate mechanical axis alignment and optimal implant positioning. The robotic group had the highest percentage of knees within ±3° of neutral alignment, affirming its precision in component orientation.

**Table 4. Radiographic Alignment and Component Positioning**

| Parameter | Group A | Group B | Group C | p-value |
|---|---|---|---|---|
| Post-op HKA Angle (degrees) | 2.3 ± 1.9 | 1.6 ± 1.4 | 0.8 ± 1.1 | 0.02 |
| % Knees within ±3° Neutral Axis | 80.4% | 88.9% | 95.7% | 0.03 |
| ICC for Radiographic Reliability | — | — | 0.91 | — |

### 3.5 Complication Profile and Implant Survivorship

Overall complication rates were low, with no significant difference across groups (*p = 0.09*). Group A recorded three cases of patellar maltracking, with one requiring secondary lateral release, and two transient peroneal nerve palsies, which resolved within 12 weeks. Group B had one case of superficial infection and one knee requiring manipulation under anesthesia for stiffness. Group C reported no major complications.

At the 24-month follow-up, implant survivorship was 100% across all groups, with no cases of aseptic loosening, deep infection, or revision. Kaplan–Meier survival curves demonstrated no divergence across cohorts (log-rank *p = 0.98*), affirming the comparable durability of the three approaches within the follow-up window. Table 5 summarizes the postoperative complications and implant survivorship. While minor complications occurred in Groups A and B, none were reported in Group C. Importantly, all groups demonstrated 100% implant survivorship at 24 months, with no revisions or deep infections observed.

**Table 5. Postoperative Complications and Implant Survivorship at 24 Months**

| Complication/Outcome | Group A | Group B | Group C |
|---|---|---|---|
| Patellar Maltracking | 3 | 0 | 0 |
| Peroneal Nerve Palsy (transient) | 2 | 0 | 0 |
| Superficial Infection | 0 | 1 | 0 |
| Manipulation under Anesthesia | 0 | 1 | 0 |
| Revision Surgery | 0 | 0 | 0 |
| 24-Month Survivorship (%) | 100% | 100% | 100% |

## 4. Discussion

This prospective cohort study compared three surgical procedures, namely medial parapatellar with lateral release, lateral parapatellar, and robotic-assisted TKA in patients who had valgus knee deformities and underwent total knee arthroplasty. The most important results are the higher accuracy and functional results of robotic-assisted methods, which do not affect the survivorship of the implants or complication rates. These findings correlate with, and in certain respects, build on previous literature concerning this complicated group of knee arthroplasties. The choice of surgery in valgus knees is controversial because of anatomical complexity and the potential for soft tissue imbalance. The results indicate that robotic-assisted TKA can provide the best alignment and soft tissue balance with a minimum requirement of adjunct releases, which decreases operative trauma and tourniquet time. Guo et al. (2018) have already reported that the lateral approach has direct access to contracted lateral structures, which decreases the necessity of aggressive medial releases. Nevertheless, evidence indicates that robotic-assisted medial techniques can provide similar, or even better, soft tissue balancing results through combining preoperative planning with intraoperative kinematic mapping. Rossi et al. (2014) highlighted the difficulty of reestablishing mechanical alignment in valgus deformities with the conventional instrumentation. The lateral approach offers superior visualization of contracted lateral structures, but it has a learning curve and a danger of patellar instability. The robotic-assisted group in the study exhibited better control of the hip-knee-ankle (HKA) angle and regular implant positioning, which was also confirmed by Victor et al. (2005), who indicated better kinematics with sophisticated guidance systems. This proves the hypothesis that intraoperative feedback can be successfully used instead of conventional, more invasive soft tissue releases.

The better functional outcomes of the postoperative period in the robotic-assisted group were confirmed by significantly higher Knee Society Scores (KSS), lower WOMAC scores, and lower VAS pain scores. These results are consistent with those of the systematic review by Wang et al. (2019), which also found improved early functional outcomes with minimally invasive and navigated procedures in valgus knees. In the same regard, Yim et al. (2013) have shown that robotic systems enable both classical and anatomical adjustment of the alignment, which results in better joint biomechanics and proprioception. Lee et al. (2018) investigated the effects of minor under-correction of valgus knees and revealed that it does not undermine functional outcomes. The study is complemented by demonstrating that robotic systems, where the alignment goals can be precise but individualized, can be inherently free of over- and under-correction. The better early rehabilitation milestones of the robotic cohort can also be attributed to the lower lateral release requirement, which is why Shah and Jain (2016) recommend soft tissue-preserving methods.

Precise radiographic alignment was another significant advantage of the robotic group. Most robotic-assisted knees were aligned to the mechanical axis of ±3 o of neutral, which was better than the medial and lateral conventional techniques. This concurs with the results of Chou et al. (2012), who demonstrated that the midvastus technique produces superior

alignment of valgus knees than the more invasive techniques. In addition, Bellemans et al. (2012) introduced the idea of constitutional alignment, which implies that robotic systems can be more accommodating of patient-specific alignment goals than imposing mechanical neutrality. Nikolopoulos et al. (2011) examined tibial tubercle osteotomy with the medial approaches and found a high level of alignment accuracy and high risks of complications. The robotic team had comparable alignment accuracy without any extra osteotomies, which implies a safer and equally efficient approach.
The three groups of the study have different approaches and complexity, all of them showed 100 percent implant survival after 24 months, no revisions, and no deep infections. Although transient peroneal nerve palsy and patellar maltracking were more common in the conventional medial group, none of them necessitated revision surgery. This confirms the results of Tucker et al. (2019), who showed great 10-year survivorship in severe valgus cases with the application of appropriate balancing methods. Fehring et al. (2001) have reported early failures of TKA because of soft tissue imbalance and malalignment that occur more frequently in valgus deformities. The evidence confirms the idea that robotic-assisted surgery helps to reduce these risks because it improves the position of the components and decreases the necessity of manipulating soft tissues. Greenberg et al. (2020) compared medial and lateral approaches in valgus knees and did not find any significant differences in the outcomes, but a slightly increased complication rate in the lateral group. Interestingly, the study did not show any sign of increased complications by either group, likely due to the standardization of surgery and patient stratification by Ranawat classification.
The good results of RATKA in the current study reflect the morphing character of technology in the complex knee arthroplasty. The traditional techniques, although still applicable, are limited to manual instrumentation, anatomical assumptions, and thus are limited in their reproducibility. Conversely, the robotic systems provide surgeons with a patient-specific roadmap in real-time and allow personal adjustment and balancing of ligaments. The rights of the release standard can also be of help, together with the management of valgus deformity, as it is discussed by Boettner et al. (2016); however, they could enjoy a significant improvement in their precision made possible by adjunctive technologies. Furthermore, Ranawat et al. (2005) pointed out that valgus knees should be classified to customize soft tissue treatment. The stratification and subgroup analyses demonstrated that robotic-assisted TKA was specifically helpful in severe Type III valgus deformities in reducing the requirement of extensive lateral releases with preservation of optimal alignment and functionality.

## 5. Conclusion

The comparative study offers an in-depth assessment of the three different surgical strategies, medial parapatellar approach with lateral release, lateral parapatellar approach, and robotic-assisted TKA, in the treatment of valgus knee deformities. Our results support the idea that although each of the methods can deliver satisfactory functional and radiological results when performed by skilled surgeons, robotic-assisted TKA is superior to traditional methods in a number of key areas. The accuracy of the coronal alignment was better in robotic-assisted surgery, intraoperative blood loss was reduced, and the reproducibility of component positioning was improved. It was most prominently linked with improved functional results at 24 months, such as higher Knee Society Scores, lower WOMAC indices, and more pain relief per VAS ratings. Such advantages were particularly seen in patients with severe (Ranawat Type III) valgus deformities, where robotic performance minimized the use of soft tissue releases without compromising on ligament balance and alignment. The lateral approach also demonstrated better early flexion and less lateral release compared to the medial approach, but was not as accurate and functional restoration as the robotic group. Notably, there was a low rate of complications and no significant differences between groups, and implant survivorship was 100 percent at 24 months with all techniques. This highlights the general safety and effectiveness of the contemporary TKA strategies when directed by proper preoperative planning and surgical skills. To conclude, robotic-assisted TKA has unambiguous benefits in the treatment of valgus knees due to the optimal biomechanical restoration and reduced intraoperative trauma. The role of robotics will probably increase in complex primary arthroplasty as technology becomes more accessible and surgical teams become more experienced. Long-term investigations that concentrate on price-effectiveness, learning curve effect, and patient-reported quality of life results will be vital in defining the future of precision-based knee arthroplasty.

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