Journal of
Clinical Medicine

MDPI

Article

Imageless Robotic-Assisted Kinematic Alignment Total Knee Arthroplasty: Surgical Technique and Preliminary Outcomes of an Initial Single-Surgeon Case Series

Ren Yi Kow [1], Yong Ng [2,3], Jeremy Tze En Lim [2], Darren Keng Jin Tay [2], Hee Nee Pang [2], Seng Jin Yeo [2] and Ming Han Lincoln Liow [2,3,*]

[1] Department of Orthopaedics, Traumatology and Rehabilitation, International Islamic University Malaysia, Kuantan 25200, Pahang, Malaysia; renyi_kow@hotmail.com
[2] Department of Orthopaedics, Singapore General Hospital, Singapore Health Services, Singapore 169608, Singapore
[3] Duke-NUS Medical School, National University of Singapore, Singapore 169857, Singapore
* Correspondence: dr.lincoln.liow@gmail.com

Abstract

Background: Robotic assistance may improve the precision of kinematic alignment total knee arthroplasty (KA-rTKA), but immediate recovery after imageless KA-rTKA remains insufficiently described. This study describes an early institutional experience with imageless robotic workflow for KA-rTKA and provides preliminary postoperative day 1 (POD1) recovery and six-month functional outcomes. **Methods**: This retrospective single-center study included 50 knees in 50 consecutive unique patients who underwent KA-rTKA, using the VELYS Robotic-Assisted Solution between January and June 2024. POD1 outcomes included range of motion (ROM), pain, and walking distance. Six-month outcomes included ROM, Knee Society Function Score (KSFS), Knee Society Knee Score (KSKS), Oxford Knee Score (OKS), and SF-36 Physical and Mental Component Summary scores (PCS and MCS). Minimum clinically important difference (MCID) attainment was assessed. **Results**: On POD1, mean ROM was 71.9° ± 21.8°, resting pain was 1.0 ± 1.4, movement-related pain was 3.8 ± 2.2, and walking distance was 19.0 ± 17.6 m. At six months, KSFS improved from 52.8 ± 20.9 to 72.1 ± 24.6, KSKS from 38.1 ± 15.4 to 83.3 ± 18.4, OKS (lower scores indicate better function) from 35.7 ± 9.0 to 20.1 ± 7.0, PCS from 31.7 ± 7.7 to 46.1 ± 10.2, and MCS from 51.4 ± 11.8 to 58.5 ± 9.6 (all $p < 0.001$). MCID achievement was high across knee-specific outcomes, at 94%, 80%, and 90% for KSKS, KSFS, and OKS respectively. **Conclusions**: Imageless KA-rTKA was associated with favorable immediate postoperative recovery and clinically meaningful six-month improvements in this single-arm series. Larger comparative studies with longer follow-up are required to determine whether these early improvements translate into superior long-term outcomes.

Keywords: kinematic alignment; total knee arthroplasty; robotic assistance; patient-reported outcome

Check for updates

Academic Editor: Nicholas David Clement

Received: 20 September 2026
Revised: 7 November 2026
Accepted: 9 November 2026
Published: 12 November 2026

Copyright: © 2026 by the authors. Licensee MDPI, Basel, Switzerland. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license.

1. Introduction

Total knee arthroplasty (TKA) is an effective surgical intervention for end-stage knee osteoarthritis, with mechanical alignment (MA) being the traditional gold standard since its introduction by Insall et al. in 1985 [1]. The MA technique aims to restore the limb to a neutral mechanical axis by aligning the femoral and tibial components perpendicular to their respective mechanical axes. Although this approach has demonstrated predictable

clinical outcomes and durable implant survivorship, it may require extensive soft-tissue releases, particularly in patients with significant coronal deformity. Moreover, up to 10% of patients remain dissatisfied following TKA, highlighting a need for alignment strategies that better account for individual patient anatomy [2].

To address these limitations, alternative alignment philosophies such as kinematic alignment (KA) have gained increasing interest. KA employs a calipered "resurfacing" technique to restore the pre-arthritic joint line and limb alignment without relying on ligament balancing [3,4]. By minimizing soft-tissue releases, KA may preserve native soft tissue tension and proprioception, potentially leading to more natural knee kinematics and improved patient satisfaction.

In parallel, robotic technology has revolutionized TKA by improving surgical precision and consistency. Robotic platforms enable three-dimensional preoperative planning, real-time intraoperative assessment, and controlled execution of bone resections based on limb alignment, joint-line orientation, and soft-tissue balance. Certain robotic systems even provide real-time three-dimensional visualization to gauge the amount of bone resected, allowing for precise intraoperative adjustments. As a result, robotic-assisted TKA (rTKA) has been associated with improved implant positioning accuracy, fewer alignment outliers, enhanced soft tissue management, and the potential for better early recovery and long-term outcomes [5,6].

Despite these advantages, the application of robotic assistance to KA-TKA remains relatively uncommon and insufficiently validated. Most KA procedures continue to be performed using manual instrumentation or caliper-based techniques, while many existing robotic platforms were originally developed around conventional alignment principles and are not universally optimized for KA execution. In response to this gap, we describe a workflow for performing kinematically aligned robotic-assisted total knee arthroplasty (KA-rTKA) using an imageless, table-mounted robotic system.

We describe our early institutional experience with an imageless, VELYS-based robotic workflow for KA-TKA together with preliminary immediate postoperative and early clinical outcomes, an aspect that remains relatively under-reported in the current literature [7]. Understanding these early outcomes is important, as they may offer insights into factors that can influence longer-term results. Therefore, this study aims to describe our surgical technique for KA-rTKA and report its immediate postoperative and early clinical outcomes.

2. Materials and Methods

2.1. Study Design

We conducted a retrospective, single-center study of consecutive patients who underwent KA-rTKA from 17th January 2024 to 25th June 2024. Of 69 knees screened during this period, 18 were excluded because of incomplete paired preoperative and postoperative radiographs required for the CPAK and alignment analyses, and one was the second knee of a bilateral patient, for which the first (index) knee was retained so that each patient contributed a single knee (Figure 1). This yielded a final cohort of 50 consecutive eligible patients with complete required data. No cases were excluded on the basis of a surgeon learning curve; the cohort included the surgeon's initial cases with this technique, providing a more representative estimate of early real-world performance. All included patients had symptomatic tricompartmental knee OA graded Kellgren-Lawrence III or IV and underwent elective primary TKA performed by a fellowship-trained senior author. Exclusion criteria included revision TKA and inflammatory arthropathies, such as rheumatoid arthritis.

All patients underwent standing full-length EOS radiographs preoperatively and at the three-month postoperative timepoint. Key preoperative and postoperative alignment parameters were measured using CARESTREAM Vue PAC Version 12.2.5.400 (Carestream

Health, Rochester, New York, NY, USA) software. Radiographic measurements were independently performed by two authors (one junior doctor and one medical student), who were blinded to patient outcomes and each other's measurements. Inter- and intraobserver reliability were assessed using intraclass correlation coefficients (ICCs) based on a two-way random-effects model with absolute agreement. For intraobserver reliability, each observer repeated measurements on the same 10 knees after a one-month interval. Excellent inter- and intraobserver reliability was demonstrated, with ICCs ranging from 0.86 to 0.91 and 0.93 to 0.96, respectively. Following MacDessi et al., the aHKA was calculated as the medial proximal tibial angle (MPTA) minus the lateral distal femoral angle (LDFA), and the JLO as their sum relative to the mechanical axis [8]. Each knee was subsequently classified into one of nine CPAK phenotypes.

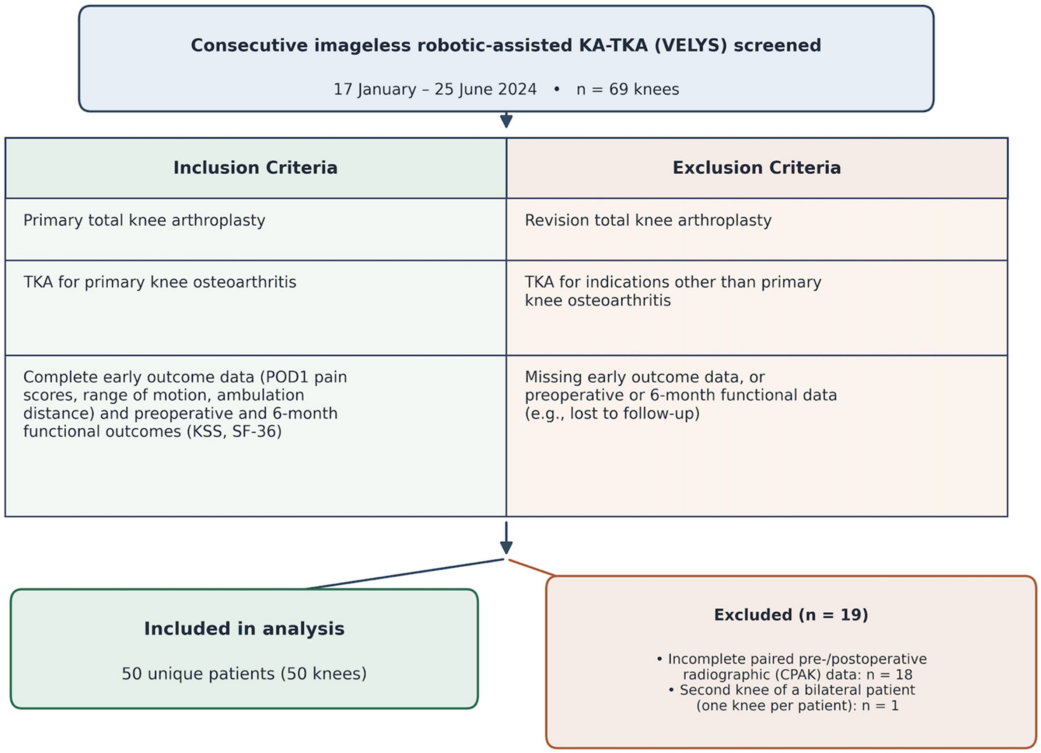

Figure 1. Patient Flow Diagram.

This retrospective study was approved by the Institutional Review Board (CIRB No. 2024/4046) and carried out in accordance with the ethical standards laid down in the 1964 Declaration of Helsinki.

2.2. Surgical Technique

All procedures were performed by a single fellowship-trained arthroplasty surgeon in a high-volume arthroplasty centre, using the VELYS™ Robotic-Assisted Solution (v1.8, DePuy Synthes, Johnson & Johnson MedTech, Warsaw, NJ, USA) and a cemented cruciate-retaining, fixed-bearing ATTUNE™ implant (DePuy Synthes); insert thickness was selected intraoperatively to achieve balanced flexion and extension gaps. The patient was positioned conventionally without a dedicated leg holder, with the knee flexed to 90° and supported by a footrest. A side support was placed adjacent to the tourniquet, and the robot was positioned proximal to the side support.

The procedure was performed using a midline skin incision followed by a medial parapatellar arthrotomy. After a conservative medial release and excision of the fat pad in

extension, a patelloplasty and lateral facetectomy were performed. The ACL and anterior horn of the lateral meniscus were excised to allow adequate exposure of the knee joint for registration. The lateral suprapatellar synovium was elevated to allow anterior femur registration. The PCL was preserved and the posterior femoral condyle was resurfaced, so that no flexion-gap imbalance was introduced. A conservative medial dissection of the anteromedial capsule was performed to obtain adequate anterior tibial exposure rather than to correct deformity; satisfactory gap balance was achieved because equal bony resections of the medial and lateral tibial plateau reproduced the native joint line, and not through an additional, deformity-correcting soft-tissue release.

Tibial and femoral tracking pins were inserted intra-incisionally, and the robotic optical arrays were securely attached to their respective bone segments. During the registration phase, anatomical landmarks were identified and digitized in accordance with the VRAS software which captured the hip center of rotation, femoral mechanical axis, femoral condyle distal and posterior articulating surfaces, tibial plateau, and malleoli. Of note, it is essential to register the tibia at the "tidemark" to ensure equal medial and lateral bony resections. To identify the tidemark, the tibia is subluxed anteriorly to expose the medial and lateral tibial plateaux. Tibial rotational reference follows the Akagi line, which bisects the tibial plateau in the mediolateral plane, while a perpendicular line (PL) bisects it in the anteroposterior plane; the intersection of these two lines corresponds to the posterior footprint of the anterior cruciate ligament (PFP), situated between the tibial eminences. The tidemark lies on normal, unworn cartilage approximately 1 cm from the PFP along the PL, both medially and laterally, and remains identifiable across standard varus, valgus, and severe posteromedial or bicompartmental wear patterns. In knees with bicompartmental wear or an indistinct cartilage transition zone, medial and lateral reference points are selected approximately 1 cm from the PFP along the PL, at the base of the tibial eminences, on a line bisecting the tibia anteroposteriorly. A resection depth of 7 mm is planned, assuming a cartilage thickness of 2 mm. Although this landmark is consistently and readily identifiable intraoperatively (Figure 2), it has not been formally assessed for intra- or inter-observer reliability, and its reproducibility across surgeons remains to be established. This step avoids registering in an area of cartilage or bony defect, which could inadvertently result in excessive tibial bone resection for the KA technique. Similarly, during registration of the femoral condyle, it is paramount to ensure that the pointer does not lift off the bone or cartilage at any time to ensure an accurate registration. A useful registration pearl is to debride remnant uneven cartilage from the distal femoral condyle to expose subchondral bone when an uneven defect is present (Figure 3).

After registration, the bone cuts are adjusted using the KA technique, depending on the thickness of the bone, to ensure equal femoral bone cuts. For example, in Figure 4, the distal medial femur showed severe wear with exposed bare bone; hence, the bone cut was 7 mm. In contrast, the lateral distal femur still had preserved cartilage. This resurfacing-based cartilage compensation was applied consistently across all resected surfaces, including the medial and lateral distal and posterior femoral condyles and the proximal tibia. Where cartilage was intact, a resection equal to the implant thickness (for example, 9 mm) was planned to resurface the joint surface. Where cartilage was partial-thickness or worn, the remaining cartilage was first removed with a curette and a 7 mm bony resection was performed under an assumption of 2 mm cartilage loss, again achieving a 9 mm resurfacing. The femoral varus/valgus and internal/external rotation were automatically adjusted based on the distal and posterior femoral cut values. Cartilage thickness was estimated visually at the time of surgery and was not measured preoperatively nor intraoperatively. The cartilage remaining on the resected specimens was subsequently measured with calipers in a separate technical validation series of 50 knees; preserved cartilage was present on

75% of measured surfaces and, where present, averaged 2.1 ± 0.8 mm, consistent with the 2 mm planning assumption. These specimen measurements however do not verify robotic cutting accuracy, which would require a direct planned-versus-achieved resection comparison (Supplementary Tables S1 and S2).

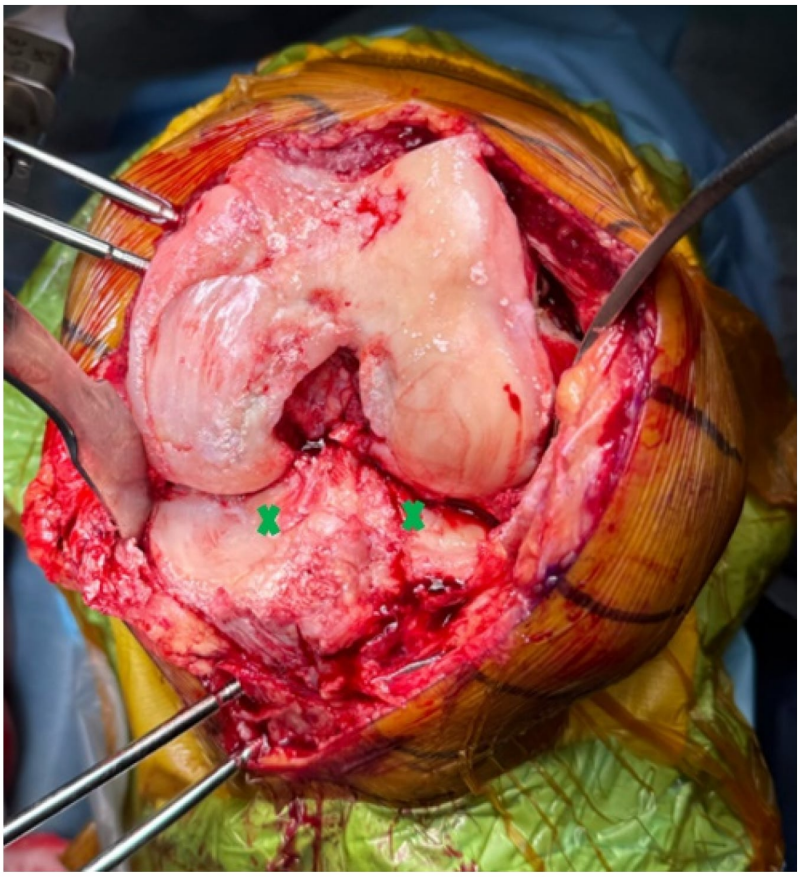

Figure 2. Intraoperative identification of the tibial registration landmark. Registration was performed at preserved cartilage adjacent to the wear defect (green crosses), rather than within the area of cartilage or bone loss.

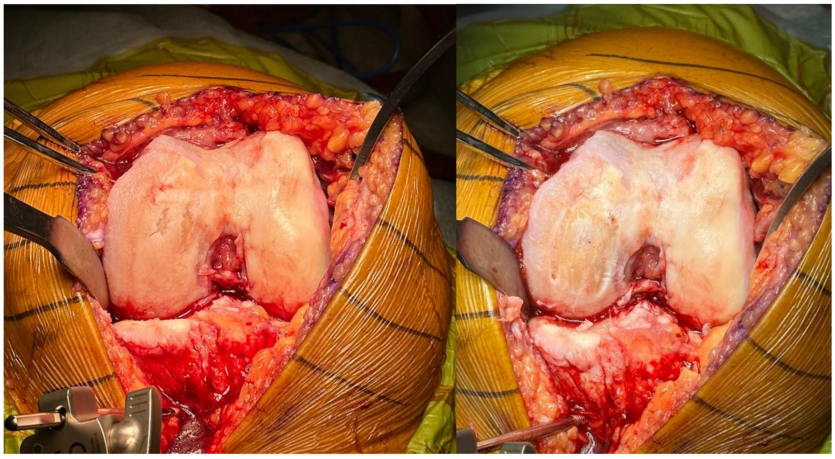

Figure 3. Pre-registration debridement technique for distal femoral condyle. An irregular articular defect on the medial femoral condyle complicates the registration due to the uneven surface (**left**) and can be debrided down to the subchondral bone using a blade and curette to create an even surface (**right**), facilitating easier registration.



Figure 4. Severe wear pattern on the medial distal femur while preserved cartilage is seen on the lateral distal femur.

In terms of the tibial resection, the preoperative medial proximal tibial angle (MPTA) and lateral distal femoral angle (LDFA) were measured from standing EOS radiographs and used as a reference. The aim was to recreate the patient's native CPAK classification [8]. By using the tibia tidemarks as the reference point during registration, the values typically ranged from 8.5 mm to 9 mm for both the medial and lateral tibial cuts. In rare cases, where the MPTA was less than 83°, a maximum tibial varus of 7° was applied as a safety constraint, consistent with established restricted KA boundaries [9,10]. For the posterior tibial slope, the surgical intent was to match the patient's native anatomy whenever possible, typically defaulting to 6°.

Proponents of the conventional KA technique insist on measuring the bone cut using a caliper. As seen in Figure 5, the measured bone fragments accurately reflect the actual amount of bone resected after factoring in the 2 mm saw blade kerf. Real-time robotic gap data, together with caliper verification, were used to guide and confirm bone resection decisions intra-operatively (Figure 6). However, it must be noted that on occasion, bone may not be cut in a smooth, straight plane in the first pass. Certain areas, such as sclerotic regions, require multiple passes with the saw to create a smooth surface, as the saw may be deflected upward when encountering hard bone.

For all cases, preoperative fasting of at least six hours was practiced, with a 50 g glucose drink given two hours before the operation. Oral omeprazole and etoricoxib were prescribed in the absence of contraindications such as gastrointestinal reflux and allergies. At the start of operation, intravenous (IV) cefazolin was given. Intraoperatively, dilute betadine irrigation was performed after implantation. A mixture of bupivacaine/adrenaline, morphine, vancomycin, triamcinolone acetonide, sodium bicarbonate, magnesium sulfate,

and ketorolac was given as a periarticular injection, and tranexamic acid was applied locally before joint capsule closure with barbed sutures. To prevent postoperative nausea and vomiting, IV dexamethasone eight mg and IV ondansetron eight mg were given at the beginning and end of the operation, respectively. Postoperatively, paracetamol, etoricoxib, and tramadol were given for analgesia. Patients underwent physiotherapy promptly, and on postoperative day one (POD1), they were given oral aspirin for venous thromboembolism prophylaxis for two weeks. All patients received standard wound care according to institutional guidelines.

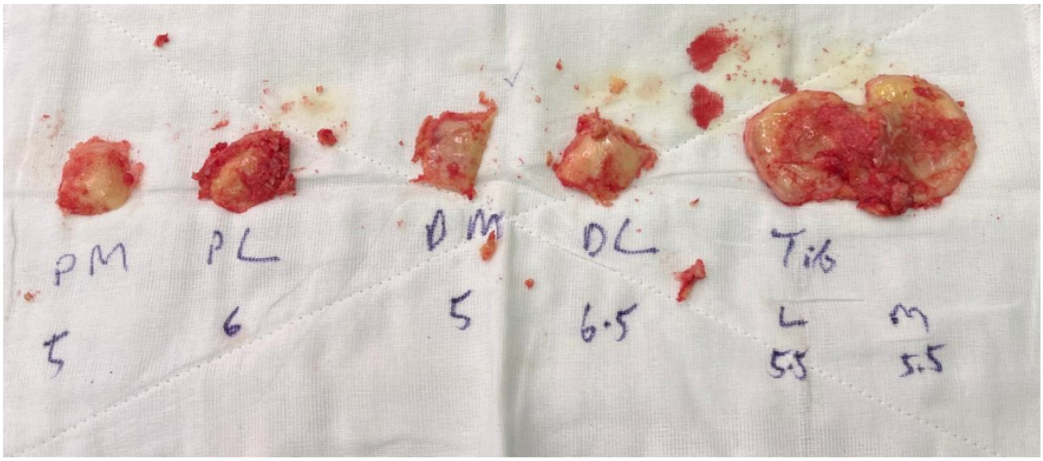

Figure 5. Caliper verification of bone resections in KA-rTKA.

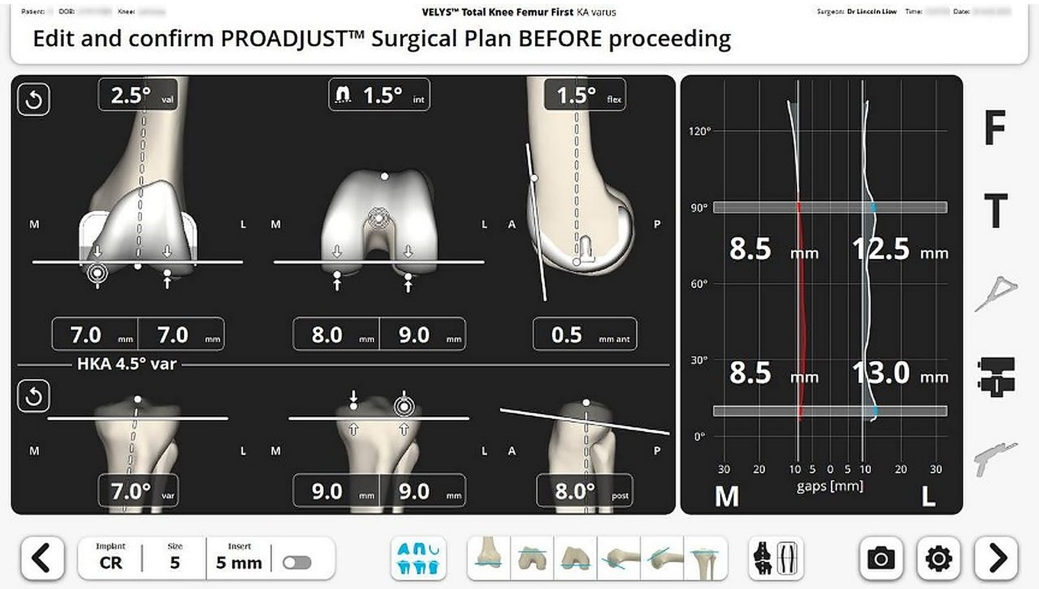

Figure 6. Pre-resection VRAS AccuGraph ligament balance data.

2.3. Data Collection

Key preoperative variables were captured by independent trained personnel at the institution's Orthopaedic Diagnostic Centre (ODC). Demographic data such as age, gender, and body mass index (BMI) were recorded and analyzed. Patients were then followed up and assessed on POD1 and at six months. Early POD1 outcomes included range of motion (ROM), walking distance, and pain scores during rest and movement using the visual analogue scale (VAS). POD1 ROM was measured with a goniometer, and walking

distance was recorded as the maximum distance ambulated during the first supervised physiotherapy session on POD1. Patient-reported outcome measures (PROMs) such as 36-item Short-Form health survey (SF-36), Knee Society Knee Score (KSKS), Knee Society Function Score (KSFS), Oxford Knee Score (OKS), were assessed. The eight SF-36 domains were summarized into two higher-order component scores: the Physical Component Score (PCS) and Mental Component Score (MCS) [11].

To ascertain if measured changes in PROMs reflected clinically meaningful improvement, the proportion of patients achieving the minimal clinically important difference (MCID) was calculated for each measure at six months. All thresholds were anchor-based estimates derived in primary TKA populations: 10 points for KSFS and 9 points for KSKS [12], and 5 points for OKS [13], 10 points for SF-36 PCS and MCS [14]. Patient satisfaction and expectation fulfillment were assessed using a Likert scale. Satisfaction was rated on a 6-point scale and dichotomized as dissatisfied ("terrible," "poor," or "fair") or satisfied ("good," "very good," or "excellent"). Expectation fulfillment was rated on a 7-point scale and similarly dichotomized as fulfilled ("Yes, totally," "Yes, almost totally," or "Yes, quite a bit") or unfulfilled ("More or less," "No, not quite," "No, far from it," or "No, not at all").

The endpoints of interest were the immediate POD1 and six-month PROMs, which were used to characterise early recovery. All radiographic alignment analyses, MCID attainment rates, and the CPAK subgroup comparisons were considered exploratory and hypothesis-generating.

2.4. Data Analyses

Continuous variables are presented as mean and standard deviation. Normality was assessed using the Shapiro–Wilk test. For between-group comparisons, Mann–Whitney U or independent samples T-test was applied based on the distribution of each variable. For within-cohort comparisons, paired T-test or Wilcoxon signed-rank test was used, based on the normality of the difference scores. Categorical variables are presented as frequencies and percentages, with between-group comparisons performed using Chi-square or Fisher's exact test as appropriate. Statistical significance was defined as $p < 0.05$. For between-group comparisons, 95% confidence intervals for mean differences were derived from the t-distribution, and standardized effect sizes (Cohen's d) are reported for the CPAK subgroup comparisons. Given the exploratory nature of the radiographic, MCID and CPAK analyses, no adjustment for multiple comparisons was performed, and the corresponding *p*-values are interpreted descriptively. All statistical analyses were performed using Python (version 3.12; Python Software Foundation, Beaverton, OR, USA).

3. Results

3.1. Demographics

A total of 50 knees from 50 unique patients underwent imageless KA-rTKA. The mean age was 69.5 ± 7.3 years, with a predominance of female patients (n = 35, 70%). The cohort had a mean body mass index (BMI) of 27.1 ± 5.5 kg/m^2 with 66% (n = 33) undergoing right-sided TKA (Table 1).

Table 1. Patient Demographics and Preoperative Status.

Variable	All Patients (n = 50)
Age, years (mean ± SD)	69.5 ± 7.3
Body mass index, kg/m^2 (mean ± SD)	27.1 ± 5.5
Female, n (%)	35 (70)
Side (right/left), n	33/17
ASA class (I/II/III/IV), n	2/48/0/0
Operative time, min (mean ± SD)	73 ± 22
Preoperative aHKA, ° (mean ± SD)	−3.2 ± 3.8
Preoperative aHKA range, °	−11.4 to 4.3
Coronal alignment—varus/neutral/valgus, n	31/13/6
CPAK phenotype (I/II/III/IV/V/VI/VII/VIII/IX), n	22/8/5/9/4/1/0/1/0
ROM (°)	120.4 ± 18.6
KSFS	52.8 ± 20.9
KSKS	38.1 ± 15.4
OKS	35.7 ± 9.0
SF-36 PCS	31.7 ± 7.7
SF-36 MCS	51.4 ± 11.8

ROM, Range of Motion; KSFS, Knee Society Function Score; KSKS, Knee Society Knee Score; OKS, Oxford Knee Score (Original Scale—lower scores indicate better function); SF-36, 36-item Short-Form health survey; PCS, Physical Component Summary; MCS, Mental Component Summary.

3.2. Radiological Alignment Parameters

Following KA-rTKA, LDFA demonstrated the most consistent restoration, with 88% of patients achieving a postoperative value within ±3° of their preoperative measurement, despite a statistically significant change (89.1° to 88.1°, $p < 0.001$). aHKA was not significantly altered postoperatively ($p = 0.48$), with 76% of patients maintaining values within ±3° of their native alignment, whereas MPTA changed modestly (85.9° to 84.9°, $p = 0.003$; 74% within ±3°). JLO showed the greatest degree of change, with a significant postoperative reduction (175.0° to 173.0°, $p < 0.001$) and the lowest restoration rate at 56% (Table 2).

Table 2. Comparison of Preoperative and Postoperative Radiological Alignment Parameters.

Variable	Preoperative (Mean ± SD, Range)	Postoperative (Mean ± SD, Range)	Absolute Change (°)	Within ±3° (%)	*p*-Value
MPTA (°)	85.9 ± 3.2 (76.0 to 93.9)	84.9 ± 2.4 (80.7 to 91.3)	2.2 ± 1.9	74.0	**0.003**
LDFA (°)	89.1 ± 2.3 (84.8 to 94.6)	88.1 ± 3.0 (78.7 to 93.8)	1.7 ± 1.3	88.0	**<0.001**
aHKA (°)	−3.2 ± 3.8 (−11.4 to 4.3)	−3.2 ± 3.6 (−11.1 to 6.8)	2.2 ± 2.6	76.0	0.477
JLO (°)	175.0 ± 4.0 (162.3 to 187.1)	173.0 ± 4.0 (164.2 to 182.8)	3.2 ± 2.1	56.0	**<0.001**

Values are presented as mean ± standard deviation. Absolute change is the mean of individual absolute differences (|postoperative − preoperative|). Within ±3° reflects the proportion of patients whose postoperative value was within 3° of their preoperative value. Bold *p*-values represent statistical significance. MPTA, Medial Proximal Tibial Angle; LDFA, Lateral Distal Femoral Angle; aHKA, Arithmetic Hip-Knee-Ankle Angle; JLO, Joint Line Obliquity.

3.3. Postoperative Outcomes at POD1 and 6 Months

On POD1, patients achieved a mean ROM of 71.9° ± 21.8 with well-controlled pain at rest (1.0 ± 1.4) and with movement (3.8 ± 2.2), and a mean walking distance of 19.0 ± 17.6 m (Table 3). At six months, significant improvements were observed across all PROMs compared to preoperative baseline, including KSFS ($p < 0.001$), KSKS ($p < 0.001$), OKS

($p < 0.001$), PCS ($p < 0.001$), and MCS ($p < 0.001$). The full summary of the six-month postoperative results can be found in Table 4. Furthermore, MCID achievement rates at six months (Figure 7) were 94% for KSKS, 90% for OKS, 80% for KSFS, 62% for SF-36 PCS and 32% for SF-36 MCS. Patient satisfaction and expectation fulfilment are reported separately as categorical outcomes; 94% were satisfied and 90% had fulfilled expectations (Table 5).

Table 3. Postoperative Day 1 Outcomes.

Outcome Measure	Postoperative Day 1
ROM (°)	71.9 ± 21.8
Pain at rest (VAS 0–10)	1.0 ± 1.4
Pain with movement (VAS 0–10)	3.8 ± 2.2
Walking distance (m)	19.0 ± 17.6

Values are presented as mean ± standard deviation. VAS, Visual Analogue Scale; ROM, Range of Motion.

Table 4. Comparison of Preoperative and Six-Month Clinical Outcomes.

Outcome Measure	Preoperative	6 Months	*p*-Value
ROM (°)	120.4 ± 18.6	117.4 ± 16.2	0.142
KSFS	52.8 ± 20.9	72.1 ± 24.6	**<0.001**
KSKS	38.1 ± 15.4	83.3 ± 18.4	**<0.001**
OKS	35.7 ± 9.0	20.1 ± 7.0	**<0.001**
SF-36 PCS	31.7 ± 7.7	46.1 ± 10.2	**<0.001**
SF-36 MCS	51.4 ± 11.8	58.5 ± 9.6	**<0.001**

Values are presented as mean ± standard deviation. Bold *p*-values represent statistical significance. ROM, Range of Motion; KSFS, Knee Society Function Score; KSKS, Knee Society Knee Score; OKS, Oxford Knee Score (Original Scale—lower scores indicate better function); SF-36, 36-item Short-Form health survey; PCS, Physical Component Summary; MCS, Mental Component Summary.

Table 5. Patient Satisfaction and Expectation Fulfilment at Six Months.

Patient Satisfaction (Rating)	n (%)
Excellent	22 (44)
Very good	15 (30)
Good	10 (20)
Fair	3 (6)
Poor	0 (0)
Terrible	0 (0)
Satisfied (good/very good/excellent)	47 (94)
Expectation fulfilment (rating)	
Yes, totally	18 (36)
Yes, almost totally	17 (34)
Yes, quite a bit	10 (20)
More or less	5 (10)
No, not quite	0 (0)
No, far from it	0 (0)
No, not at all	0 (0)
Fulfilled (yes, totally/almost totally/quite a bit)	45 (90)

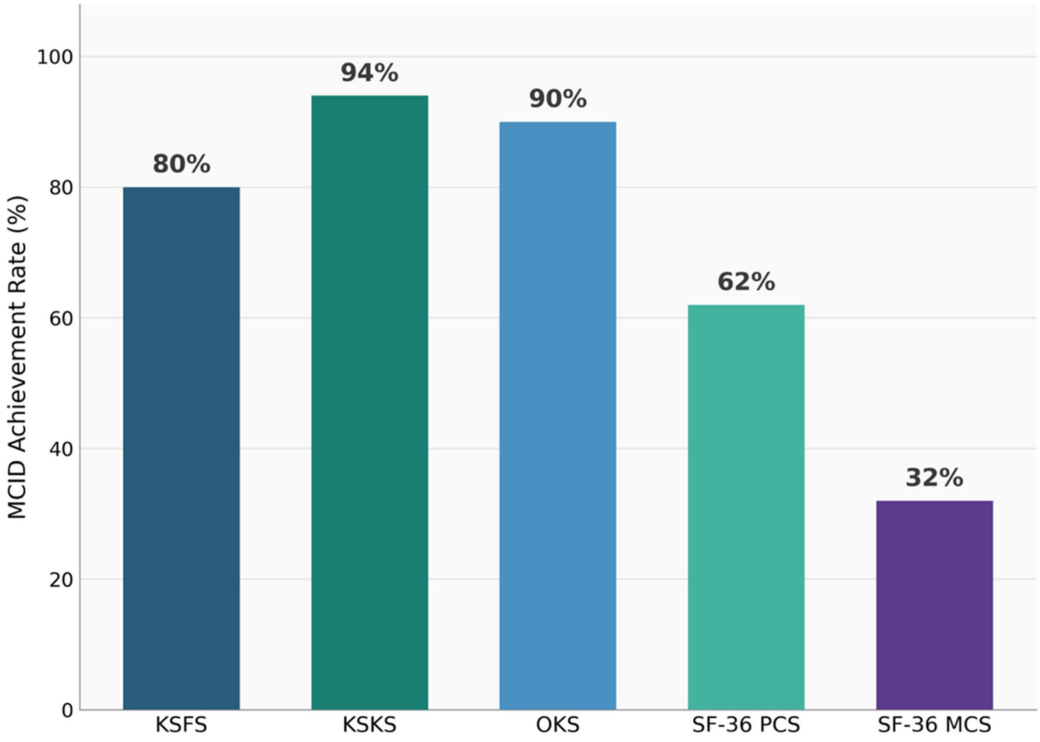

Figure 7. MCID Achievement Rates at 6 Months. KSFS, Knee Society Function Score; KSKS, Knee Society Knee Score; OKS, Oxford Knee Score (Original Scale—lower scores indicate better function); SF-36, 36-item Short-Form health survey; PCS, Physical Component Summary; MCS, Mental Component Summary.

3.4. Complications Within the Study Cohort

Over the six-month follow-up period, all 50 procedures were completed as planned using the imageless robotic workflow, with no intraoperative complications and no robotic registration or workflow failures requiring conversion to conventional manual instrumentation. There were no wound complications, no superficial or deep periprosthetic joint infections, and no symptomatic venous thromboembolic events. There were no cases of postoperative stiffness requiring manipulation under anaesthesia and no symptomatic instability. There were no unplanned readmissions, reoperations, or revision procedures within the study period. Complications were ascertained from the institutional electronic medical record and operative and clinic records over the six-month follow-up period.

3.5. Postoperative Outcomes Between CPAK Restoration and CPAK Change Groups

When comparing patients who experienced CPAK restoration versus CPAK change as a secondary analysis, the two groups were similar at baseline for most demographic and preoperative measures, although preoperative ROM differed by approximately 10.8° and baseline SF-36 MCS also differed between groups (Table 6); 54% (27 of 50) of patients achieved CPAK restoration (i.e., same preoperative and postoperative CPAK phenotype). No statistically significant difference was detected between groups in any POD1 outcome, including ROM ($p = 0.423$), pain at rest ($p = 0.350$), pain with movement ($p = 0.721$), and walking distance ($p = 0.776$). At six months, no statistically significant differences were detected between groups across the measures assessed; however, the confidence intervals do not exclude potentially meaningful differences (Tables 7 and 8).

Table 6. Baseline Demographics and Preoperative Outcomes by CPAK Group.

Variable	CPAK Restoration	CPAK Change	*p*-Value
Demographics			
Age (years)	70.2 ± 6.7	68.7 ± 8.0	0.465
BMI (kg/m^2)	26.5 ± 5.3	27.7 ± 5.7	0.482
Gender, n (%)			0.355
Female	17 (63.0)	18 (78.3)	
Male	10 (37.0)	5 (21.7)	
Side, n (%)			0.767
Right	17 (63.0)	16 (69.6)	
Left	10 (37.0)	7 (30.4)	
Preoperative Outcome Measures			
ROM (°)	115.6 ± 21.8	126.4 ± 11.2	0.063
KSFS	56.1 ± 20.8	49.0 ± 20.9	0.215
KSKS	37.7 ± 16.6	38.5 ± 14.3	0.866
OKS	34.4 ± 9.2	37.2 ± 8.7	0.312
SF-36 PCS	31.6 ± 8.0	31.8 ± 7.6	0.945
SF-36 MCS	54.9 ± 7.4	47.3 ± 14.6	**0.035**

Values are presented as mean ± standard deviation. Bold *p*-values represent statistical significance. ROM, Range of Motion; KSFS, Knee Society Function Score; KSKS, Knee Society Knee Score; OKS, Oxford Knee Score (Original Scale—lower scores indicate better function); SF-36, 36-item Short-Form health survey; PCS, Physical Component Summary; MCS, Mental Component Summary.

Table 7. Comparison of Postoperative Day 1 Outcomes between CPAK Restoration and CPAK Change Groups.

Outcome Measure	CPAK Restoration	CPAK Change	Mean Difference (95% CI)	Cohen's d	*p*-Value
ROM (°)	74.2 ± 21.6	69.2 ± 22.1	5.0 (−7.5 to 17.5)	0.23	0.423
Pain at rest (VAS 0–10)	0.8 ± 1.2	1.2 ± 1.5	−0.4 (−1.2 to 0.4)	−0.29	0.350
Pain with movement (VAS 0–10)	3.7 ± 2.2	4.0 ± 2.3	−0.2 (−1.5 to 1.1)	−0.10	0.721
Walking distance (m)	20.9 ± 21.3	16.8 ± 11.9	4.1 (−5.9 to 14.2)	0.24	0.776

Values are presented as mean ± standard deviation. CPAK restoration defined as postoperative CPAK phenotype matching preoperative CPAK phenotype. VAS, Visual Analogue Scale; ROM, Range of Motion.

Table 8. Comparison of Six-Month Outcomes between CPAK Restoration and CPAK Change Groups.

Outcome Measure	CPAK Restoration	CPAK Change	Mean Difference (95% CI)	Cohen's d	*p*-Value
ROM (°)	115.8 ± 18.6	119.8 ± 12.0	−4.0 (−13.8 to 5.8)	−0.25	0.414
KSFS	76.3 ± 23.6	67.2 ± 25.5	9.1 (−6.1 to 24.2)	0.37	0.218
KSKS	83.1 ± 19.5	83.6 ± 17.6	−0.5 (−12.0 to 11.0)	−0.03	0.770
OKS	19.0 ± 6.5	21.4 ± 7.4	−2.3 (−6.6 to 2.0)	−0.33	0.141
SF-36 PCS	46.8 ± 10.2	45.2 ± 10.4	1.5 (−4.8 to 7.9)	0.15	0.503
SF-36 MCS	59.0 ± 6.2	57.8 ± 12.6	1.2 (−4.8 to 7.2)	0.12	0.779

Values are presented as mean ± standard deviation. ROM, Range of Motion; KSFS, Knee Society Function Score; KSKS, Knee Society Knee Score; OKS, Oxford Knee Score (Original Scale—lower scores indicate better function); SF-36, 36-item Short-Form health survey; PCS, Physical Component Summary; MCS, Mental Component Summary.

4. Discussion

In the present study, KA-rTKA using the described workflow was associated with favourable immediate postoperative recovery and clinically meaningful improvement at six months. On POD1, patients demonstrated a mean ROM of 71.9°, a low resting VAS pain score of 1.0, and a mean walking distance of 19.0 m. By six months, all PROMs (KSFS, KSKS, SF-36 PCS and SF-36 MCS) improved significantly as well. Collectively, these findings suggest KA-rTKA was associated with early gains in knee function and health-related quality of life within the first six months, while maintaining ROM. However, in the absence of a control group these observations cannot be causally attributed to the technique.

These results are consistent with the conceptual rationale for KA; by resurfacing the arthritic joint while preserving the patient's native alignment, KA may reduce the need for soft-tissue releases, which may, in turn, support early pain control and functional recovery [15]. Existing studies have generally supported the safety and reproducibility of KA-rTKA, although randomised controlled trials comparing KA and MA have not consistently demonstrated superior mid- to long-term outcomes for either strategy [16–19]. Nevertheless, these studies mostly focus on the mid- to long-term outcomes, with few investigating the immediate postoperative outcomes after KA-rTKA [20]. Although robotic assistance and KA are each individually established, their combination using an imageless, table-mounted system has been less fully characterised; a recent scoping review of the VELYS platform identified a paucity of described kinematic-alignment workflows and of immediate recovery data for imageless robotic TKA [21]. Accordingly, the present study contributes a reproducible imageless KA-rTKA workflow together with immediate (POD1) and early six-month descriptive outcomes that are seldom reported together, although direct comparative conclusions cannot be drawn in the absence of a control group.

The significant postoperative reduction in JLO, together with its comparatively lower restoration rate (56% within ±3°), reflects small, concurrent reductions in both the MPTA (85.9° to 84.9°; mean signed change −1.0°) and the LDFA (89.1° to 88.1°; mean signed change −1.0°), consistent with JLO being defined as their sum (MPTA + LDFA); each reduction is individually modest and together they account for the approximately 2° reduction in mean JLO. This reduction was not driven by the restricted-KA boundary. In the 9 knees (18%) with a preoperative MPTA below 83°, the tibial constraint in fact raised the MPTA toward the 83° limit (mean 81.3° to 83.3°) and preserved their JLO (mean 170.4° to 170.9°); the overall JLO reduction instead arose from the 41 knees with a preoperative MPTA of 83° or greater (mean JLO change −2.5°). The comparatively lower ±3° restoration rate for JLO therefore reflects the summation of two individually small femoral and tibial angular changes against a relatively strict threshold. Reassuringly, a preoperative MPTA below 84° has been shown not to compromise two-year clinical outcomes after unrestricted KA-TKA [22], suggesting that the small alignment changes observed here are of limited clinical consequence.

The postoperative MPTA range reported in Table 2 (80.7° to 91.3°) includes values beyond the intended 7° tibial-varus constraint; the difference between the intraoperative, KA–referenced plan and the standing full-length radiographic measurement may be due to the compounding effects of postoperative weight-bearing, minor robotic plan-to-achieved execution variances, and radiographic measurement differences [23,24]. The introduction of gravity, physiological muscle forces, and slight variations in patient limb rotation during the three-month standing full-length radiographs can naturally shift the final weight-bearing alignment beyond the initial intraoperative target.

The clinical significance of these early findings warrants careful interpretation. Effective immediate pain control and early functional recovery are not merely markers of a smooth perioperative course. Severe acute postoperative pain is a recognised risk factor for the development of chronic postsurgical pain after TKA, hence the low resting pain observed on

POD1 in our cohort may carry prognostic relevance beyond the immediate period [25]. Our findings are consistent with emerging literature suggesting that personalized alignment may be particularly relevant in the early recovery phase. In conventional calipered KA, Vinograd et al. [26] found a 0.8-day reduction in length of stay, faster POD1 Timed Up and Go performance, and better early postoperative OKS and Knee Injury and Osteoarthritis Outcome Score (KOOS). Similarly, Lychagin et al. [27] showed an early ROM advantage and a more favourable pain trajectory with restricted KA compared with robotic-assisted MA. However, the degree to which such early advantages translate into superior long-term results remains uncertain. Notably, high early postoperative ROM does not reliably predict long-term ROM or functional outcomes [28], and postoperative ROM itself correlates poorly with PROMs in the Asian population [29]. Consequently, although our early results are encouraging and clinically meaningful for the immediate recovery phase, whether they translate into durable functional gains or improved implant survivorship remains unknown.

In the present study, 54% (27 of 50) of patients achieved CPAK phenotype restoration, with no statistically significant differences detected in PROMs between the CPAK restoration and change groups, although these groups were imbalanced at baseline (notably preoperative ROM and SF-36 MCS) and the confidence intervals do not exclude clinically relevant differences. Accordingly, the absence of statistical significance should not be interpreted as evidence that CPAK restoration confers no clinical benefit as this exploratory subgroup comparison was under-powered. In the current literature, many have studied the clinical relevance and impact of robotic assistance on CPAK restoration [30]. Several studies in MA and FA cohorts have reported no consistent association between CPAK restoration and superior PROMs [31–33]. Notably, a recent systematic review concluded that there is no consistent association between CPAK phenotype restoration and improved PROMs after primary TKA [34].

An additional consideration when interpreting our results is the heterogeneity in how KA is defined and executed across the literature. Published studies have investigated inverse KA, restricted KA, unrestricted KA, adjusted MA, and FA, all of which fall under the broader umbrella of personalized alignment but are not interchangeable [35]. These approaches differ in their alignment targets, soft-tissue philosophy, accepted boundaries, and reliance on robotic planning or intraoperative balancing. Therefore, we believe our findings are best positioned within the broader framework of personalized alignment TKA, while recognizing that the specific outcomes observed may be related to the technical details of our KA-rTKA workflow.

This study has several limitations. First, its retrospective, single-arm, single-centre design limits generalisability as it is subjected to selection and observational bias, and the absence of a control group (e.g., MA-TKA or conventional calipered KA-TKA) precludes comparative conclusions about the technique's relative effectiveness. Second, the six-month follow-up characterises only immediate and early recovery and cannot address the mid- to long-term durability of alignment, functional gains, or implant survivorship. Third, although the sample size was adequate for preliminary descriptive analysis, it limited meaningful phenotype-specific comparison as a subset of patients did not achieve the MCID in certain domains, which warrants further investigation into predictors of suboptimal recovery. Finally, these analyses should be interpreted within the exploratory framework of a preliminary case series. Beyond the descriptive POD1 and six-month PROMs, the radiographic, MCID, and CPAK subgroup analyses were hypothesis-generating and should therefore be regarded as preliminary.

Nevertheless, this preliminary study supports the feasibility and favorable early recovery profile of KA-rTKA using an imageless robotic-assisted technique. Adequately powered, prospectively designed comparative studies with longer follow-up are warranted to confirm

these findings and to determine whether the early improvements translate into superior long-term outcomes and implant survivorship.

5. Conclusions

This preliminary study suggests that imageless KA-rTKA is associated with favorable immediate postoperative recovery and clinically meaningful improvement in knee function and health-related quality of life by six months. These findings support KA-rTKA as a feasible personalized alignment strategy, although comparative studies with longer follow-up are required to determine whether these early improvements translate into superior long-term outcomes.

Supplementary Materials: The following supporting information can be downloaded at: https://www.mdpi.com/article/10.3390/jcm15228851/s1, Supplementary Table S1. Calipered Resection Measurements; Supplementary Table S2. Polyethylene Insert Thickness in the Technical Validation Series.

Author Contributions: Conceptualization, M.H.L.L.; methodology, R.Y.K., Y.N., J.T.E.L.; software, R.Y.K., Y.N.; validation, R.Y.K., Y.N., J.T.E.L.; formal analysis, R.Y.K., Y.N.; investigation, R.Y.K., Y.N., J.T.E.L.; resources, M.H.L.L.; data curation, R.Y.K., Y.N., J.T.E.L.; writing—original draft preparation, R.Y.K., Y.N., J.T.E.L.; writing—review and editing, R.Y.K., Y.N., J.T.E.L., D.K.J.T., H.N.P., S.J.Y.; visualization, R.Y.K., Y.N.; supervision, M.H.L.L. All authors have read and agreed to the published version of the manuscript.

Funding: This research received no external funding.

Institutional Review Board Statement: The study was conducted in accordance with the Declaration of Helsinki, and approved by the SingHealth Centralised Institutional Review Board (ECOS Ref: 2024-4046 and Approval Date: 5 March 2025).

Informed Consent Statement: Patient consent was waived due to the use of de-identified data.

Data Availability Statement: The data that support the findings of this study are available on reasonable request from the corresponding author. The data are not publicly available due to privacy or ethical restrictions.

Conflicts of Interest: The authors declare no conflicts of interest. S.J.Y.: The author declares that he is a paid consultant, paid presenter or speaker and research support for DePuy, A Johnson & Johnson Company; M.H.L.L.: The author declares that he is on the editorial or governing board of Arthroplasty and Journal of Arthroplasty. He is also a paid consultant for DePuy, A Johnson & Johnson Company and Stryker. He is also a paid presenter or speaker for DePuy, A Johnson & Johnson Company and Stryker.

References

1. Insall, J.N.; Binazzi, R.; Soudry, M.; Mestriner, L.A. Total knee arthroplasty. *Clin. Orthop. Relat. Res.* **1985**, *192*, 13–22. [CrossRef] [PubMed]
2. DeFrance, M.J.; Scuderi, G.R. Are 20% of Patients Actually Dissatisfied Following Total Knee Arthroplasty? A Systematic Review of the Literature. *J. Arthroplast.* **2023**, *38*, 594–599. [CrossRef] [PubMed]
3. Howell, S.M.; Akhtar, M.; Nedopil, A.J.; Hull, M.L. Reoperation, Implant Survival, and Clinical Outcome After Kinematically Aligned Total Knee Arthroplasty: A Concise Clinical Follow-Up at 16 Years. *J. Arthroplast.* **2024**, *39*, 695–700. [CrossRef] [PubMed]
4. Cinelli, V.; Marescalchi, M.; Picchi, A.; De Mattia, G.; Andriollo, L.; Fidanza, A.; Logroscino, G.; Sangaletti, R.; Benazzo, F.; Rossi, S.M.P. Total Knee Arthroplasty and the Evolution of Coronal Alignment: From Mechanical to Personalized Strategies. *J. Pers. Med.* **2025**, *15*, 524. [CrossRef] [PubMed] [PubMed Central]
5. Chen, J.; Chua, H.Y.J.; Lim, J.T.E.; Tay, D.K.J.; Tan, M.H.; Liow, M.H.L. VELYS robotic-assisted total knee replacement leads to improved mobility, reduction in hospitalisation, surgical duration, and better psychological outcomes: A propensity score matched analysis. *Arthroplasty* **2025**, *7*, 55. [CrossRef] [PubMed]
6. El Motassime, A.; Tanzi Germani, G.; Sangaletti, R.; Andriollo, L.; Cinelli, V.; Benazzo, F.; Rossi, S.M.P. Imageless robotic assisted TKA: A systematic review. *J. Orthop.* **2026**, *75*, 154–162. [CrossRef] [PubMed] [PubMed Central]

7. Alsheikh, K.; Alotaibi, F.; Alnaqa, F.; Alshahir, A.; Almunyif, T.; Alshebel, M.; Raza, M.L.; Alsebayel, F.M. Patient-reported outcomes of kinematically aligned robotic total knee replacement: A single center, single surgeon experience. *J. Robot. Surg.* **2026**, *20*, 501. [CrossRef] [PubMed] [PubMed Central]
8. MacDessi, S.J.; Griffiths-Jones, W.; Harris, I.A.; Bellemans, J.; Chen, D.B. Coronal Plane Alignment of the Knee (CPAK) classification. *Bone Jt. J.* **2021**, *103-B*, 329–337. [CrossRef] [PubMed] [PubMed Central]
9. MacDessi, S.J.; Allom, R.J.; Griffiths-Jones, W.; Chen, D.B.; Wood, J.A.; Bellemans, J. The importance of joint line obliquity: A radiological analysis of restricted boundaries in normal knee phenotypes to inform surgical decision making in kinematically aligned total knee arthroplasty. *Knee Surg. Sports Traumatol. Arthrosc.* **2022**, *30*, 2931–2940. [CrossRef] [PubMed]
10. Winnock de Grave, P.; Kellens, J.; Luyckx, T.; Tampere, T.; Lacaze, F.; Claeys, K. Inverse Kinematic Alignment for Total Knee Arthroplasty. *Orthop. Traumatol. Surg. Res.* **2022**, *108*, 103305. [CrossRef] [PubMed]
11. Ware, J.E.; Kosinski, M.; Bayliss, M.S.; McHorney, C.A.; Rogers, W.H.; Raczek, A. Comparison of methods for the scoring and statistical analysis of SF-36 health profile and summary measures: Summary of results from the Medical Outcomes Study. *Med. Care* **1995**, *33*, AS264–AS279. [PubMed]
12. Lizaur-Utrilla, A.; Gonzalez-Parreño, S.; Martinez-Mendez, D.; Miralles-Muñoz, F.A.; Lopez-Prats, F.A. Minimal clinically important differences and substantial clinical benefits for Knee Society Scores. *Knee Surg. Sports Traumatol. Arthrosc.* **2020**, *28*, 1473–1478. [CrossRef] [PubMed]
13. Clement, N.D.; MacDonald, D.; Simpson, A.H.R.W. The minimal clinically important difference in the Oxford knee score and Short Form 12 score after total knee arthroplasty. *Knee Surg. Sports Traumatol. Arthrosc.* **2014**, *22*, 1933–1939. [CrossRef] [PubMed]
14. Escobar, A.; Quintana, J.M.; Bilbao, A.; Aróstegui, I.; Lafuente, I.; Vidaurreta, I. Responsiveness and clinically important differences for the WOMAC and SF-36 after total knee replacement. *Osteoarthr. Cartil.* **2007**, *15*, 273–280. [CrossRef] [PubMed]
15. Howell, S.M. Calipered Kinematically Aligned Total Knee Arthroplasty: An Accurate Technique That Improves Patient Outcomes and Implant Survival. *Orthopedics* **2019**, *42*, 126–135. [CrossRef] [PubMed]
16. Dossett, H.G.; Arthur, J.R.; Makovicka, J.L.; Mara, K.C.; Bingham, J.S.; Clarke, H.D.; Spangehl, M.J. A Randomized Controlled Trial of Kinematically and Mechanically Aligned Total Knee Arthroplasties: Long-Term Follow-Up. *J. Arthroplast.* **2023**, *38*, S209–S214. [CrossRef] [PubMed]
17. Young, S.W.; Walker, M.L.; Bayan, A.; Briant-Evans, T.; Pavlou, P.; Farrington, B. The Chitranjan S. Ranawat Award: No Difference in 2-year Functional Outcomes Using Kinematic versus Mechanical Alignment in TKA: A Randomized Controlled Clinical Trial. *Clin. Orthop. Relat. Res.* **2017**, *475*, 9–20. [CrossRef] [PubMed] [PubMed Central]
18. Young, S.W.; Sullivan, N.P.T.; Walker, M.L.; Holland, S.; Bayan, A.; Farrington, B. No Difference in 5-year Clinical or Radiographic Outcomes Between Kinematic and Mechanical Alignment in TKA: A Randomized Controlled Trial. *Clin. Orthop. Relat. Res.* **2020**, *478*, 1271–1279. [CrossRef] [PubMed]
19. Garg, N.; Gupta, N.; Khatri, K.; Bansal, N.; Bansal, K.; Passi, A. Functional, patient-reported, and radiographic outcomes of kinematic versus mechanical alignment in robotic total knee arthroplasty: A systematic review and meta-analysis. *Knee* **2026**, *60*, 104412. [CrossRef] [PubMed]
20. Ng, Y.; Lim, J.T.E.; Kow, R.Y.; Pang, H.N.; Tay, D.K.J.; Yeo, S.J.; Liow, M.H.L. Imageless kinematic versus CT-based functional alignment in robotic-assisted total knee arthroplasty: A propensity score–matched comparative study. *J. Orthop.* **2026**, *77*, 29–35. [CrossRef] [PubMed]
21. Morrison, S.R.; Hall, A.J.; Clement, N.D.; Gee, C.; Chopra, S.; Clarke, J.V. The VELYS robotic-assisted solution: A strategic technology evaluation informed through scoping review. *Comput. Assist. Surg.* **2026**, *31*, 2699503. [CrossRef] [PubMed]
22. Ng, Y.; Lim, W.S.R.; Lam, L.Z.L.; Escarda, J.L.; Lee, M.; Yeo, S.J. Preoperative Medial Proximal Tibial Angle of Less Than 84° Does Not Compromise Two-Year Clinical Outcomes After Unrestricted Kinematic Alignment Total Knee Arthroplasty: A Propensity Score-Matched Study. *J. Arthroplast.* **2026**, *in press*. [CrossRef] [PubMed]
23. Gieroba, T.J.; Marasco, S.; Babazadeh, S.; Di Bella, C.; van Bavel, D. Arithmetic hip knee angle measurement on long leg radiograph versus computed tomography-inter-observer and intra-observer reliability. *Arthroplasty* **2023**, *5*, 35. [CrossRef] [PubMed] [PubMed Central]
24. Anglin, C.; Brimacombe, J.M.; Wilson, D.R.; Masri, B.A.; Greidanus, N.V.; Tonetti, J.; Hodgson, A.J. Intraoperative vs. weightbearing patellar kinematics in total knee arthroplasty: A cadaveric study. *Clin. Biomech.* **2008**, *23*, 60–70. [CrossRef] [PubMed]
25. Knezevic, N.N.; Syed, O.; Kabir, C.; Patel, A.; Rao Shuai, I.; Tharian, A.R. The Impact of Acute Postoperative Pain in Developing Chronic Pain after Total Knee Arthroplasty. *Neurol. Int.* **2024**, *16*, 459–469. [CrossRef] [PubMed] [PubMed Central]
26. Vinograd, O.; Essa, A.; Steinberg, N.; Mitchnik, I.Y.; Avraham, D.; Rotem, I.; Vinograd, A.; Beer, Y.; Shohat, N.; Bar-Ziv, Y. Prospective Comparison of Short-Term Outcomes in Kinematic and Mechanical Alignment Total Knee Arthroplasty. *Clin. Pract.* **2025**, *15*, 162. [CrossRef] [PubMed]
27. Lychagin, A.V.; Gritsyuk, A.A.; Elizarov, M.P.; Gritsuk, A.A.; Gavlovsky, M.Y.; Tomboidi, K.K.; Kalinsky, E.B.; Rosenberg, N. Mechanical Versus Restrictive Kinematic Alignment in Robotic-Assisted Total Knee Arthroplasty: A Randomized Controlled Trial. *Diagnostics* **2025**, *15*, 2524. [CrossRef] [PubMed]

28. Köglberger, P.; Wurm, A.; Coraça-Huber, D.; Krismer, M.; Oberaigner, W.; Liebensteiner, M. High range of motion in the first ten postoperative days after TKA does not predict superior outcome in the long run. *Arch. Orthop. Trauma Surg.* **2022**, *142*, 2497–2501. [CrossRef] [PubMed] [PubMed Central]
29. Soon, E.L.; Bin Abd Razak, H.R.; Tan, C.S.; Tan, H.C.A. Postoperative range of motion does not correlate with patient reported outcome scores in Asians after total knee arthroplasty. *J. Arthroplast.* **2014**, *29*, 2285–2288. [CrossRef] [PubMed]
30. Lim, J.T.E.; Ng, Y.; Chen, J.W.; Kow, R.Y.; Pang, H.N.; Tay, D.K.J.; Yeo, S.J.; Liow, M.H.L. Does Robotic Assistance Improve Restoration of Coronal Plane Alignment of the Knee in Kinematically Aligned Total Knee Arthroplasty? A Comparative Alignment Study. *J. Orthop.* **2026**, *78*, 84–90. [CrossRef]
31. Kraus, K.R.; Deckard, E.R.; Buller, L.T.; Meding, J.B.; Meneghini, R.M. The Mark Coventry Award: Does Matching the Native Coronal Plane Alignment of the Knee Improve Outcomes in Primary Total Knee Arthroplasty? *J. Arthroplast.* **2025**, *40*, S3–S11. [CrossRef] [PubMed]
32. Bollars, P.; Feyen, H.; Nathwani, D.; Albelooshi, A.; Ettinger, M.; De Corte, R.; Schotanus, M.G.M. Postoperative changes in CPAK-classification do not significantly influence patient-reported outcome measures following conventional or robotic-assisted total knee arthroplasty: A randomised controlled trial. *Knee Surg. Sports Traumatol. Arthrosc.* **2025**, *33*, 3333–3340. [CrossRef] [PubMed]
33. Bertugli, E.; Zambianchi, F.; Batailler, C.; Bazzan, G.; Lustig, S.; Catani, F. Change of CPAK class does not affect functional outcomes in robotic arm-assisted total knee arthroplasty performed with functional alignment. *Knee Surg. Sports Traumatol. arthrosc.* **2025**, *33*, 1773–1783. [CrossRef] [PubMed]
34. Hajiaghajani, S.; Poursalehian, M.; Salmannezhad, A.; Culler, M.W.; Yun, A.G.; Heckmann, N.D. Restoring the coronal plane alignment of the knee (CPAK) phenotype does not consistently improve patient-reported outcomes after primary total knee arthroplasty: A systematic review. *Knee Surg. Sports Traumatol. Arthrosc.* **2026**, *34*, 4133–4144. [CrossRef] [PubMed]
35. Saffarini, M.; Canetti, R.; Henry, J.; Michalewska, K.; Müller, J.H.; Hirschmann, M.T.; Eka, E.K.A. Sparse and inconsistent reporting of pre- and post-operative radiographic angles of total knee arthroplasty using true unrestricted kinematic alignment: An umbrella review and secondary meta-analysis. *Knee Surg. Sports Traumatol. Arthrosc.* **2025**, *33*, 997–1014. [CrossRef] [PubMed]

Disclaimer/Publisher's Note: The statements, opinions and data contained in all publications are solely those of the individual author(s) and contributor(s) and not of MDPI and/or the editor(s). MDPI and/or the editor(s) disclaim responsibility for any injury to people or property resulting from any ideas, methods, instructions or products referred to in the content.