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Improved accuracy and reproducibility of a novel CT-free robotic surgical assistant for medial unicompartmental knee arthroplasty compared to conventional instrumentation: a cadaveric study

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Abstract

Purpose Alignment errors in medial unicompartmental knee arthroplasty (UKA) predispose to premature implant loosening and polyethylene wear. The purpose of this study was to determine whether a novel CT-free robotic surgical assistant improves the accuracy and reproducibility of bone resections in UKA compared to conventional manual instrumentation.

Methods Sixty matched cadaveric limbs received medial UKA with either the ROSA® Partial Knee System or conventional instrumentation. Fifteen board-certified orthopaedic surgeons with no prior experience with this robotic application performed the procedures with the same implant system. Bone resection angles in the coronal, sagittal and transverse planes were determined using optical navigation while resection depth was obtained using calliper measurements. Group comparison was performed using Student's *t* test (mean absolute error), *F* test (variance) and Fisher's exact test (% within a value), with significance at $p < 0.05$.

Results Compared to conventional instrumentation, the accuracy of bone resections with CT-free robotic assistance was significantly improved for all bone resection parameters ($p < 0.05$), other than distal femoral resection depth, which did not differ significantly. Moreover, the variance was significantly lower (i.e. fewer chances of outliers) for five of seven parameters in the robotic group ($p < 0.05$). All values in the robotic group had a higher percentage of cases within 2° and 3° of the intraoperative plan. No re-cuts of the proximal tibia were required in the robotic group compared with 40% of cases in the conventional group.

Conclusion The ROSA® Partial Knee System was significantly more accurate, with fewer outliers, compared to conventional instrumentation. The data reported in our current study are comparable to other semiautonomous robotic devices and support the use of this robotic technology for medial UKA.

Level of evidence Cadaveric study, Level V.

Keywords Unicompartmental knee arthroplasty · Robotic surgery · Conventional instrumentation · Bone resection · Accuracy · ROSA® Partial Knee System

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Introduction

Unicompartmental knee arthroplasty (UKA) has proven effective for patients with arthritis primarily isolated to a single compartment, with optimized kinematics and function. It has resulted in improved patient satisfaction, less postoperative opioid requirements, decreased morbidity and lower perioperative costs compared to total knee arthroplasty (TKA) [1–5]. Despite these outcomes, higher failure rates are observed when performed by lower volume surgeons [2, 6].

Component malposition and soft tissue imbalance are common mechanisms of aseptic failure in UKA [7, 8]. Errors of more than 2° (as much as 40–60% of manual cases) or 3° in the coronal plane and excessive tibial slope may predispose to mechanical failure [9, 10]. Robotic assistance has been advanced in an attempt to simplify UKA procedures, neutralize the impact of surgeon inexperience, reduce instrumentation, enhance the precision of bone preparation, component alignment and soft tissue balance, and ultimately improve clinical results and implant durability [11–17]. However, several of these platforms require computed tomography (CT) scanning for preoperative planning [15, 16, 18, 19], adding to the cost of care, and putting patients at risk for radiation exposure [11, 19, 20]. These factors have led to increasing use of CT-free robotic systems for UKA and TKA [15, 16, 18, 19, 21, 22].

A novel CT-free robotic system has been introduced that relies on intraoperative landmark mapping, quantitative soft tissue balancing, and robotic control of a constrained cut guide to enhance precision and reproducibility of bone resections, and has been shown in TKA to be significantly more accurate and reproducible than conventional instrumentation [22]. The purpose of the current study was to evaluate the ability of this novel CT-free robotic system to provide more accurate and reliable bone resections compared to conventional manual instrumentation.

Materials and methods

Study design

This matched-pair study was conducted on 60 knees in 30 specimens (21 males and 9 females) with a mean age of 80 ± 12 years (39–81–97, min–median–max). For each specimen, one knee was randomly assigned to the robotic group and the contralateral to conventional instrumentation.

Fifteen board-certified arthroplasty surgeons each performed two conventional and two robotic UKA procedures, using the Persona® Partial Knee (PPK) implant system (Zimmer Biomet, Warsaw IN, USA). Surgeon experience was balanced with regards to prior robotic experience (8 high [min 30 cases] vs 7 low), conventional UKA volume (8 high [> 15 UKAs/year] vs 7 low), and PPK implant use (7 high [> 15 PPKs/year] vs 8 low).

Conventional UKA procedure

Surgeons performed the medial UKA procedure in accordance with the most current surgical technique of the PPK implant system, using their preferred surgical workflow. Surgeons with less experience with UKA procedures, in general, or the PPK implant system, specifically, received standardized training that consisted of a theoretical component and hands-on UKA training on sawbones. Surgeons were asked to follow a standardized resection plan (Table 1).

Robotic UKA procedure

Given the novelty of this application, none of the surgeons had experience on the ROSA® Partial Knee System (Zimmer Biomet, Warsaw IN, USA; Fig. 1), but eight (53%) had prior robotic experience, either with the ROSA® Knee System application or with other robotic systems. All surgeons received standardized training consisting of theoretical and hands-on surgical training on sawbones.

Standardized steps of the ROSA® Partial Knee System were performed: (1) calibrating the force sensor and draping the robotic arm; (2) positioning the robotic and camera units in the operating room; (3) registering the robotic arm; (4) installing bone trackers. The femoral and tibial landmarks specific to a medial UKA were acquired, followed by performing a knee evaluation to register knee range of motion (ROM), varus/valgus laxity ranges at different flexion angles, and the maximum medial joint space at 0° and 90° of flexion. Intraoperative planning was performed with the objective of minimizing the tibial resection depth while also minimizing the likelihood of requiring a re-cut (same as conventional group; Table 1).

The robotic system positions and holds the ROSA® Persona Partial Knee Medial Cut Guide, as determined by the intraoperative plan, allowing the surgeon to perform the proximal tibial and distal femoral resections with standard power tools (allows easy transition to a TKA if necessary). After each resection, a laxity assessment was performed at 0° and 90° of flexion to evaluate the impact of the resection on the surrounding soft tissue balance, and allow for adjusting the plan if needed. The femur preparation was completed using standardized femoral finishing guides, and trials were implanted for a final knee evaluation.

Table 1 Standardized resection plan for the conventional and robotic groups

Parameter	Target value	
	Conventional group	Robotic group[a]
Tibia		
Tibia depth	Selected by the surgeon (minimize depth and chances of re-cut)	Selected by the surgeon (minimize depth and chances of re-cut)
Tibia V/V	0° (EM guide aligned with tibia mechanical axis in coronal plane)	Selected by the surgeon (usually 0°)
Tibia A/P	5° posterior (EM guide aligned with tibia mechanical axis in sagittal plane)	Selected by the surgeon (usually 5° posterior)
Tibia I/E	0° with tibia anteroposterior axis (saw blade aligned with femoral head centre)[b]	Selected by the surgeon (usually 0°)[c]
Femur		
Femur depth	6.5 mm (built-in spacer-block)	Selected by the surgeon (usually 6.5 mm)
Femur V/V	Parallel to tibia resection (spacer-block on tibia resection)	Parallel to tibia resection (built-in software)
Femur F/E	0° (surgeons were asked to perform resection in extension)	Selected by the surgeon (usually 0°)

V/V varus/valgus, *A/P* anterior/posterior slope, *I/E* internal/external rotation (sagittal resection), *F/E* flexion/extension, *EM* extramedullary

[a]Values selected in the planning panel (rounded to 0.5° or 0.5 mm) were recorded in the robot log file as part of the intraoperative plan

[b]The surgeons were asked to aim for the femoral head centre (same as being parallel to the femoral mechanical axis) to be comparable to the robotic group

[c]The tibial AP axis in the ROSA software is determined by projecting the femoral mechanical axis on the tibial plateau during the flexion pose

Fig. 1 The ROSA® Partial Knee System comprising the ROSA® Recon Robotic Unit (left) and the ROSA® Recon Optical Unit (right). Four different cut guides exist depending on the operating room setup. The system uses optical tracking technology combined with a robotic arm to position and hold the cut guide to the desired location to achieve the intraoperative plan. After each resection, the surgeon can perform an optional laxity assessment to evaluate the state of the soft tissues and readjust the intraoperative plan if necessary

Measurement of bone resection angles

For both groups, a validated optical navigation system (Sesamoid® Plasty with software ORTHOsoft® Unicondylar Knee 1.0 Universal, Zimmer CAS, Montreal, Canada) was used to measure the bone resection angles, an established method for this purpose [23, 24]. Using machined aluminium jigs representing a perfect femur and tibia, the accuracy of the optical navigation system was found to be 0.22° ± 0.17° (coronal plane), 0.19° ± 0.12° (sagittal plane) and 0.25° ± 0.47° (transverse plane) (mean absolute error (MAE) ± standard deviation (SD)).

Bone trackers were installed on the femur and tibia without interfering with the instrumentation, and the landmarking points (previously marked) were acquired using the optical navigation system (conventional group) or using both the robotic and optical navigation systems independently (robotic group). After each bone resection, a handheld validation tool from the optical navigation system was placed on the resected surface to record alignment (Fig. 2).

Measurement of bone resection depth

After each bone resection, a calibrated digital calliper, with blunted tips to avoid surface penetration (Mitutoyo #500-196-30, accuracy of ± 0.02 mm; Fig. 2), was used to measure the resected bone wafer. The measurement was taken where the landmark point was previously marked.

Statistical analysis

Sample size was evaluated a priori by comparing conventional instrumentation and robotic UKA data from the literature since there was no accuracy data available on the current system. Using the success/fail rate for conventional versus robotic instrumentation for UKA [25], it was determined

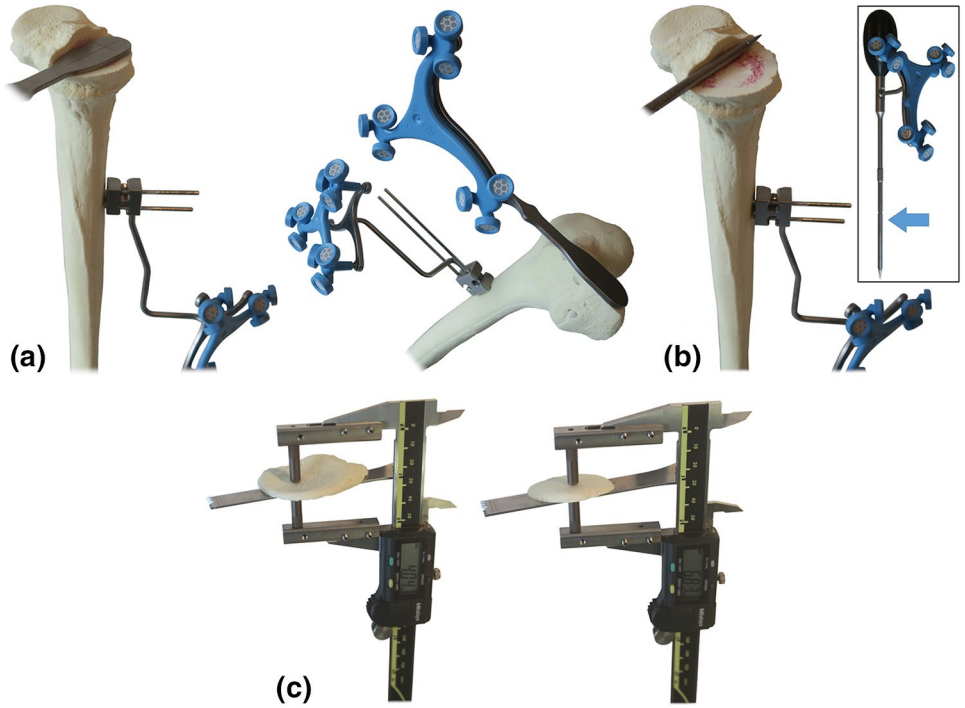

Fig. 2 Measurement of bone resections. **a** Coronal and sagittal angles: the validation paddle was applied to the resected surface of the tibia or femur (performed in triplicates); **b** transverse angle (sagittal resection): the long axis of the registration pointer (arrow in insert) was applied at the intersection of the proximal tibial resections (performed in triplicates); **c** the bone resection depth was acquired by measuring the bone wafer flat on a saw blade where the landmark was previously marked (left: tibia; right: femur), using a calibrated digital calliper and blunted tips (value verified by a second reader)

that a minimum sample size of 28 knees per group should be used ($\alpha = 0.05$, $\beta = 0.20$; power 80%). Using the root mean square error (RMSE) of many studies [12, 14, 17, 25–31], the calculated power for a sample size of 30 knees per group was at least 71% for all parameters except for Tibia V/V.

After testing for data normality, descriptive statistics were calculated (MAE, SD, 95% confidence interval (CI), absolute min and max, percentage of cases within a certain value). Group comparison of the MAE, variance and percentage of cases within a certain value was performed using paired Student's t test, F test and Fisher's exact test, respectively, with significance determined at $p < 0.05$ (SAS version 9.4). Statistical outliers were kept in the data set unless they could be taken out with an empirical justification (detailed in Tables).

Results

Bone resection angles

The accuracy of bone resection angles was significantly improved for all parameters in the robotic group compared to the conventional group ($p < 0.05$; Table 2). Moreover, the variance was significantly lower (i.e. fewer chances of an outlier) for four of five parameters in the robotic group (Table 2). All parameters in the robotic group had a higher percentage of cases within 2° and 3° of the intraoperative plan, with many significantly higher compared to the conventional group (Table 3). In the robotic group, all parameters had at least 97% of cases within 3°, except for Tibia I/E.

Bone resection depth

The accuracy of the tibial resection depth was significantly improved in the robotic group compared to the conventional group ($p < 0.05$, Table 4). For the femoral resection depth, both groups did not differ significantly ($p > 0.05$, Table 4). The variances were significantly lower for the tibial resection depth in the robotic group and for the femoral resection depth in the conventional group. The percentage of cases within 2 mm was significantly higher for the tibial resection depth in the robotic group, and did not differ significantly from the conventional group for the femoral resection depth (Table 5).

Incidence of re-cuts

No bone re-cuts of the proximal tibia were required in the robotic group compared to 40% of cases in the conventional group (with 6.7% of conventional cases with two re-cuts). In all cases, a re-cut was made in depth of resection to address tightness in extension and flexion. No re-cuts of the distal femur were observed for either group.

Table 2 Accuracy of reproducing the intraoperative plan for bone resection angles

Parameter	Mean |Δ| ± SD [CI 95%] (°)			|Min|, |Max| (°)	
	Conventional	Robotic	*p* value*	Conventional	Robotic
Sample size	30[a]	30[b]		30[a]	30[b]
Tibia V/V	1.76 ± 1.04 [1.37–2.14]	1.18 ± 0.88 [0.85–1.52]	0.039	0.01, 4.39	0.07, 3.07
Tibia A/P	2.17 ± 1.85 [1.48–2.86]	1.22 ± 0.97** [0.85–1.59]	0.036	0.18, 7.72	0.02, 3.75
Tibia I/E	6.96 ± 4.87 [5.11–8.81]	3.12 ± 2.11** [2.31–3.92]	< 0.001	0.08, 18.83	0.23, 7.60
Femur V/V	2.76 ± 1.74 [2.11–3.41]	1.07 ± 0.92** [0.72–1.41]	< 0.001	0.32, 7.07	0.09, 3.90
Femur F/E	5.79 ± 4.68 [4.05–7.54]	1.08 ± 0.86** [0.75–1.40]	< 0.001	0.35, 20.05	0.06, 3.97

Accuracy was determined as the mean absolute error (mean |Δ|) between the optical navigation value (average of three readings) and the intraoperative plan value

*Group comparison of the Mean |Δ| using Student's *t* test

**Group comparison of the variance using *F* test, $p < 0.05$

SD standard deviation, *CI* confidence interval, *V/V* varus/valgus, *A/P* anterior/posterior slope, *I/E* internal/external rotation (sagittal resection), *F/E* flexion/extension

[a]Sample size of 29 for Tibia I/E (measurement omission)

[b]Sample size of 29 for all tibia parameters (fractured tibial plateau because of soft bone)

Table 3 Proportion of cases within 2° and 3° of the intraoperative plan for bone resection angles

Parameter	% within 2°			% within 3°		
	Conventional	Robotic	*p* value*	Conventional	Robotic	*p* value*
Sample size	30[a]	30[b]		30[a]	30[b]	
Tibia V/V	63.3%	79.3%	n.s.	90.0%	96.6%	n.s.
Tibia A/P	53.3%	82.8%	0.025	76.7%	96.6%	n.s.
Tibia I/E	6.9%	41.4%	0.005	17.2%	51.7%	0.012
Femur V/V	40.0%	83.3%	0.001	53.3%	96.7%	< 0.001
Femur F/E	16.7%	86.7%	< 0.001	26.7%	96.7%	< 0.001

V/V varus/valgus, *A/P* anterior/posterior slope, *I/E* internal/external rotation (sagittal resection), *F/E* flexion/extension; *n.s.* not significant ($p > 0.05$)

*Group comparison of the % of cases using Fisher's exact test

[a]Sample size of 29 for Tibia I/E (measurement omission)

[b]Sample size of 29 for all tibia parameters (fractured tibial plateau because of soft bone)

Table 4 Accuracy of reproducing the intraoperative plan for bone resection depths

Parameter	Mean |Δ| ± SD [CI 95%] (mm)			|Min|, |Max| (mm)	
	Conventional	Robotic	*p* value*	Conventional	Robotic
Sample size	30	29[a]		30	29[a]
Tibia depth	1.42 ± 1.35 [0.92–1.93]	0.77 ± 0.51** [0.58–0.97]	0.020	0.07, 4.95	0.09, 1.92
Femur depth	0.45 ± 0.35** [0.32–0.58]	0.71 ± 0.66 [0.46–0.96]	n.s.	0.02, 1.12	0.02, 2.47

Accuracy was determined as the mean absolute error (Mean |Δ|) between the calliper measurement value and the intraoperative plan value

SD standard deviation, *CI* confidence interval

*Group comparison of the Mean |Δ| using Student's *t* test

**Group comparison of the variance using *F* test, $p < 0.05$

[a]One case with fractured tibial plateau because of soft bone (tibia) and one case where measurement was not possible (femur). n.s.: not significant ($p > 0.05$)

Table 5 Proportion of cases within 2 mm of the intraoperative plan for bone resection depths

Parameter	% within 2 mm		
	Conventional	Robotic	*p* value*
Sample size	30	29[1]	
Tibia depth	73.3%	100%	0.005
Femur depth	100%	89.7%	n.s.

*Group comparison of the % of cases using Fisher's exact test

n.s. not significant ($p > 0.05$)

[a]One case with fractured tibial plateau because of soft bone (tibia) and one case where measurement was not possible (femur)

Discussion

The key findings of this study were more precise femoral and tibial bone resection angles in the coronal, sagittal and axial planes, as well as a more accurate tibial resection depth with the CT-free robotic system compared to conventional instrumentation. Additionally, the robotic group produced more reproducible bone resections (fewer outliers) for most of the parameters studied.

The current study found comparable improvement in bone resection accuracy as with other robotic systems, including applications that have and have not required preoperative CT imaging for planning [12, 14, 17, 25, 32] (Tables 6, 7 and 8). When using the image-free Navio™ robotic sculpting tool (Smith and Nephew, Memphis TN, USA), tibial component coronal alignment was within 3° of the plan in 89%, compared to 35% when using conventional methods [33]. It was found that 75% of femoral components and 90% of tibial components were within 3° of coronal and sagittal targets when using the Mako™ CT-based system (Stryker, Kalamazoo MI, USA) [12]. In our study, 97% of tibial and femoral bone resections were accurate within 3° of the targeted plan in both the coronal and sagittal planes. Furthermore, our study showed equivalent or higher rates of accuracy within 2° in the coronal and sagittal planes compared to the results of two studies using the Mako system (Table 7) [12, 25].

Compared to other systems, the robotic system in this study was less accurate for Tibia I/E (Tables 6, 7 and 8). Despite being significantly more accurate than our conventional group, the axial rotation of the sagittal resection had the highest error of all parameters (also observed in other studies; Tables 7 and 8). For all systems, this could reside

Table 6 Mean positional errors compared to alternative CT-free robotic system

Parameter	Mean error ± SD		Min, Max	
	ROSA® Partial[a]	Navio [17][b]	ROSA® Partial	Navio [17]
Tibia V/V (°)	1.2 ± 0.9	1.98 ± 1.52	−1.7, 3.1	−3.85, 5.03
Tibia A/P (°)	1.2 ± 1.0	1.51 ± 1.39	−3.8, 0.7	−4.11, 4.99
Tibia I/E (°)	3.1 ± 2.1	1.17 ± 1.13	−7.6, 5.4	−1.24, 3.84
Tibia depth (mm)	0.8 ± 0.5	0.79 ± 0.64	−1.9, 1.8	−2.37, 2.11
Femur V/V (°)	1.1 ± 0.9	1.88 ± 1.31	−1.4, 3.9	−5.21, 4.27
Femur F/E (°)	1.1 ± 0.9	1.04 ± 0.82	−4.0, 0.9	−2.87, 2.18
Femur depth (mm)	0.7 ± 0.7	0.72 ± 0.51	−2.5, 1.2	−1.33, 2.43

SD standard deviation, *V/V* varus/valgus, *A/P* anterior/posterior slope, *I/E* internal/external rotation (sagittal resection), *F/E* flexion/extension

[a]Current study; error on bone resections

[b]Error on implant components

Table 7 Percentage of cases within 2° of plan compared to CT-based robotic system and conventional instrumentation

Parameter	ROSA® Partial [a]	Mako [25] [b]	Mako [12] [b]	Conventional [25] [b]	Conventional %[a]
Tibia V/V (°)	79%	58%	79%	41%	63%
Tibia A/P (°)	83%	80%	74%	22%	53%
Tibia I/E (°)	41%	48%	58%	19%	7%
Femur V/V (°)	83%	70%	79%	28%	40%
Femur F/E (°)	87%	57%	68%	26%	17%

V/V varus/valgus, *A/P* anterior/posterior slope, *I/E* internal/external rotation (sagittal resection), *F/E*: flexion/extension

[a]Current study; percentage calculated on bone resections

[b]Percentage calculated on implant components

Table 8 Root mean square errors (RMSE) comparing several robotic systems and conventional instrumentation

Parameter	ROSA® Partial[a]	Mako [25][b]	Mako [12][b]	Navio [17][b]	Conventional [25][b]	Conventional[a]
Tibia V/V (°)	1.47	2.58	1.5	2.43	3.71	2.03
Tibia A/P (°)	1.54	1.64	1.9	1.98	4.43	2.83
Tibia I/E (°)	3.75	2.97	3.0	1.87	7.95	8.45
Tibia depth (mm)	0.92	NA	0.8	1.01	NA	1.95
Femur V/V (°)	1.40	2.09	2.6	2.27	5.09	3.24
Femur F/E (°)	1.37	3.35	2.3	1.31	6.87	7.40
Femur depth (mm)	0.96	NA	1.2	0.88	NA	0.57

V/V varus/valgus, *A/P* anterior/posterior slope, *I/E* internal/external rotation (sagittal resection), *F/E*: flexion/extension, *NA* not available

[a]Current study; error on bone resections

[b]Error on implant components

in the difficulty to accurately establish the anteroposterior (AP) axis of the tibial plateau due to a great variability in determining tibial bony landmarks [34]. For the system evaluated, this may be explained both by the sagittal resection performed using a cut slot that allows more freedom of movement than other resections, and the use of a sagittal saw blade that is relatively flexible, which could increase its skiving. While the accuracy of Tibia I/E is less accurate for ROSA® Partial Knee System compared to other systems, a prior study has shown that rotation of a fixed-bearing UKA tibial component of up to ± 3°, as observed in this study, does not adversely impact functional outcomes [35]. Moreover, in fixed-bearing UKA, malrotation of up to ± 5° may not affect the Western Ontario and MacMaster (WOMAC) and Knee Society scores enough to reach the minimum clinically important difference [36–38]. As for the PPK conventional instrumentation, it does not have a cut slot for the sagittal resection. Additionally, conventional instrumentation requires aiming at anatomical landmarks which can add to the inaccuracy of the sagittal resection, like aligning with the mechanical axis of the femur (creates the AP axis of the tibial plateau).

Similar to Ponzio et al. [39], our study also showed that the robotic group provided more accurate resection depth of the tibial surface compared to conventional instrumentation. More conservative tibial resection, achievable with robotics, allows the use of smaller tibial inserts and places the tibial component on stronger bone, which makes it less likely to collapse and loosen [39]. Additionally, it makes the conversion to TKA easier, with less likelihood of requiring tibial augments or stems in the event that revision surgery is necessary [39, 40]. Interestingly, we observed no re-cuts of the proximal tibia in the robotic group compared to an incidence of 40% when using conventional instrumentation. There is a paucity of data on re-cuts in the UKA literature but one might think the percentage observed in this study for conventional instrumentation is higher than normal practice. This could be due to the use of cadaveric specimens, which do not always have osteoarthritis. Nevertheless, this shows the predictive capability of robotic systems regarding the relationship between bone resections and soft tissue balance. Additionally, it could potentially optimize surgical efficiency, reduce chances of fracture (less over-resection and avoidance of additional pin use) and decrease thermal necrosis due to multiple sawing episodes.

In the current study, conventional instrumentation did not accurately achieve the femoral flexion/extension angle in many cases. This may be more related to the user and/or anatomical factors in the cadaveric limbs, such as omission or difficulty to position the leg at exactly 0° extension during the distal femoral resection (e.g. larger patients with big thighs) or the presence of flexion contracture, rather than to errors inherent to the instrumentation itself. On the other hand, the comparable precision achieved for the femoral resection depth with conventional instrumentation compared to the robotic group was not unexpected. Conventional instrumentation used a spacer-block, which rigidly links the femoral cut slot to the femoral bone reference (most distal point of the medial condyle), therefore improving accuracy and reducing variability in the resection (manufacturing tolerances of a spacer-block are smaller than the error generated by optical navigation in the robotic group). All root mean square error values for the femoral resection depth appear similar between robotic systems, and they are also all greater than our conventional group (Table 8).

This study had several limitations. The surgeon group consisted of 15 orthopaedic surgeons with varying levels of experience with both the robotic system and conventional instrumentation. On the other hand, given the potential value of robotic methods for mitigating the impact of surgeon inexperience, particularly during the learning curve of one's experience, one could argue that one study strength is that it is generalizable to surgeons with variable levels of experience. A second limitation

is the use of cadaveric specimens, which typically have less osteoarthritis and deformities than clinical cases, and sometimes poorer bone quality. Nonetheless, the ability to determine the accuracy of bone resections compared to the plan should not be impacted using a cadaveric model. A third limitation comes from the optical navigation measurements that are dependent on the equipment's accuracy, shown to be less than 0.25° in this study (with calliper measurements at 0.02 mm). The accuracy results presented correlate well with the resolution of the measurement tools used (Tables 2 and 4). Additionally, it was recently demonstrated that intraoperatively measured component alignment, using optical navigation, is comparable to CT-based measurements [41].

Future clinical study is planned to determine whether similar results are attainable among additional surgeons with varying degrees of experience with UKA and robotics, as well as determining the learning curve associated with this robotic system, in terms of surgical efficiencies and alignment measures. Finally, the clinical relevance of the improved accuracy shown here will need to be demonstrated in terms of durability as well as clinical, functional and radiologic outcomes.

Conclusion

In conclusion, this cadaveric study showed that bone preparation using the ROSA® Partial Knee System in UKA was significantly more accurate, with fewer outliers, compared to conventional manual instrumentation and supports the use of this robotic technology for medial UKA.

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Declarations

Conflict of interest Dr. Jess H. Lonner is a paid consultant for Zimmer Biomet and Smith & Nephew. Dr. Ari D. Seidenstein, Dr. Michael A. Charters, Dr. W. Trevor North, Dr. Nathan L. Cafferky, Dr. Sridhar M. Durbhakula and Dr. Atul F. Kamath are paid consultants for Zimmer Biomet.

Ethical approval The study did not include research with animals or living human participants and was declared exempt by the local institutional review board.

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