1-1-2023

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Journal of Orthopaedic Surgery

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Journal of Orthopaedic Surgery
31(1) 1–6

DOI: 10.1177/10225536221138986
journals.sagepub.com/home/osj
SAGE

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Abstract

Introduction: Robotic-arm assisted unicompartmental knee arthroplasty (RA-UKA) has demonstrated accurate component positioning and excellent outcomes for medial components. However, there is a paucity of literature on lateral compartment RA-UKA. The purpose of our study was to assess the midterm clinical outcomes and survivorship of lateral RA-UKA.

Methods: This study was a retrospective review of a single-center prospectively maintained cohort of 33 patients (36 knees) indicated for lateral UKA. Perioperative, and postoperative two- and five-year Knee injury Osteoarthritis Outcome Score (KOOS), Western Ontario and McMaster Universities Osteoarthritis Score (WOMAC), and Forgotten Joint Score (FJS) patient reported outcome measures were collected. Five-year follow-up was recorded in 29 patients (32 knees).

Results: Mean follow up was 5.1 ± 0.1 years. Mean age and BMI was 70.9 ± 7.2 years and 29.0 ± 4.2 kg/m2, respectively. At discharge, mean distance walked was 273.4 ± 70.4 feet, and mean pain score was 2.0 ± 2.5. At 2-year follow up, mean KOOS, WOMAC, and FJS were 75.1 ± 13.5, 15.0 ± 7.2, and 81.0 ± 23.3, respectively. At 5-year follow up, mean KOOS, WOMAC, and FJS were 75.3 ± 14.6, 14.9 ± 5.0, and 75.8 ± 27.4, respectively. Mean change in KOOS and WOMAC were 35.6 ± 27.1 and 11.7 ± 13.4 ($p < .001$ and $p < .001$). 94% of patients were very satisfied/satisfied, 3% neutral, and 3% dissatisfied. 91% met activity expectations, and 59% were more active than before. Survivorship was 100% at 5 years.

Discussion: In this study, lateral RA-UKA demonstrated significantly improved clinical outcomes, high patient satisfaction, met expectations, and excellent functional recovery at midterm follow up. Comparative studies are needed to determine differences between robotic-assisted and conventional lateral UKA, as well as TKA.

Keywords

Lateral partial knee arthroplasty, robotic-assisted, unicompartmental

Date received: 14 February 2022; Received revised 21 October 2022; accepted: 30 October 2022

Introduction

Unicompartmental knee arthroplasty (UKA) is a reliable and effective surgery for isolated medial or lateral compartment end-stage osteoarthritis and has become increasingly popular in recent years.[1,2] In comparison to total knee arthroplasty (TKA), UKA has multiple advantages

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including faster recovery,[3] better range of motion,[4] fewer complications,[5] and easier revisions.[6] Despite these advantages, registry data reports UKA has a higher revision rate when compared to TKA reported failures due to iatrogenic surgical factors including lower limb post-operative malalignment and component malpositioning.[2,7] Robotic assisted UKA (RA-UKA) was developed to improve surgeon reliability and reproducibility of the procedure. In comparison to conventional UKA, RA-UKA has been shown to have comparable functional outcomes,[8] improved component positioning,[9,10] and fewer revisions[2] combined with excellent overall survivorship.[11]

While RA-UKA is successful, an overwhelming majority of the surgeries performed are for the medial compartment versus the lateral compartment.[12,13] Lateral UKA is historically thought to be more technically challenging because of the overall lower volume due to less lateral compartment osteoarthritis encountered by a surgeon and increased laxity found at the lateral compartment which has been associated with a higher incidence of bearing dislocation.[14,15] Lower surgical volume is likely due to the association of lateral osteoarthritis with patellofemoral involvement, ACL deficiency, and MCL laxity which can contraindicate for lateral UKA. Additionally, specific anatomic concerns exist with lateral UKA such as the patellar impingement on the femoral component and increased risk of mediolateral component incongruency.[14] Given these concerns, there is a question if lateral RA-UKA can overcome the difficulties seen with conventional lateral UKA.

The purpose of this study is to assess the clinical and patient recorded outcomes of a cohort of lateral RA-UKA from a single center at short term follow-up. We hypothesize lateral RA-UKA will have excellent mid-term outcomes and survivorship.

Methods

Thirty-three consecutive patients (36 knees) underwent a lateral RA-UKA between 2009 to 2013 and were followed prospectively in a single center cohort. Institutional review board approval was obtained at the institution in order to collect and analyze this data. Inclusion criteria included all patients over 21 years of age with lateral compartment osteoarthritis only and ligamentous integrity who required primary lateral UKA. These patients failed non-operative management of their joint disease and were candidates for partial joint replacement because of pain and joint stiffness that interfered with their performance of normal daily activities. Exclusion criteria included patients with active infection, patients with not enough bone stock to allow for insertion and fixation of the components, patients with insufficient soft tissue integrity to allow for stability, patients with neurological or muscular deformity that did not allow for control of the knee, patients unable cognitively to complete health-related quality of life forms, excessive patellofemoral and/or medial compartment osteoarthritis, and pregnant women (Table 1). All patients had radiographic evidence of osteoarthritis in the lateral compartment and received the Restoris MCK (Mako Surgical Corp. (Stryker), Fort Lauderdale, FL) UKA implant. All surgeries were performed with the Mako System (Mako Surgical Corp. (Stryker), Fort Lauderdale, FL).

A lateral parapatellar approach was used with a skin incision just lateral to patella was made and a lateral arthrotomy from 1 cm proximal to patella to 1 cm distal to tibia was used. We used a gap balancing technique using robotics where in 10 degrees of flexion the valgus deformity is manually corrected towards neutral mechanical alignment until there is appropriate tension of lateral structures. A data point is obtained with the robot which measures the gap between the femur and tibia. The maximum correction of the valgus deformity is to 0° and it is not overcorrected into varus. Then the knee is flexed to 90° and lateral tissues are tensioned manually using a curved osteotome and another data point is collected measuring the gap between the femur and the tibia. Then the implants are adjusted from the initial pre-op plan to the final plan using a CT scan with the Mako software so the gaps between the femoral component and tibial component plus 8 mm poly are at 0.6 mm in both flexion and extension. Next, the bone is then burred using the robot arm and the knee is trialed with 8 mm poly and subsequently thicker poly inserts as indicated by manual ligamentous testing combined with digital assessment of alignment using the Mako software.

Five-year and 2-year postoperative follow-up was recorded in 29 patients (32 knees), 12 left knees and 20 right knees. Data collected at all follow-up timepoints included demographic information (date of birth, date of surgery, body mass index [BMI], laterality), patient satisfaction with Mako operative knee (very satisfied, satisfied, neutral, dissatisfied, very dissatisfied), patient activity expectation, support with walking, and patient recorded outcome measures (PROMs). PROMs collected were the reduced Knee injury Osteoarthritis Outcome Score (KOOS), reduced Western Ontario and McMaster Universities Osteoarthritis Score (WOMAC), and Forgotten Joint Score (FJS). The Reduced WOMAC is a truncated version of the WOMAC which is designed to assess pain, disability and joint stiffness in the OA patient. The Reduced KOOS assesses the patient's opinion regarding their knee and its associated OA. Poor outcomes are reported with a lower score and good outcomes with a higher score. The FJS determines how aware the patient is of their joint in their everyday life. Patient questionnaires were given to patients at their office visit. For patients that did not come in for visits, they were be sent via regular mail or email. Intraoperative data collected included tourniquet time, total operating room time,

Table 1. Inclusion and exclusion criteria.

Inclusion criteria	Exclusion criteria
• Lateral osteoarthritis and indicated for primary lateral unicompartmental arthroplasty only	• Active infections
• Age over 21 years old	• Poor bone stock
	• Insufficient soft tissue stability
	• Neurological or muscular deformity
	• Unable to cognitively complete postoperative outcome measures
	• Pregnant women
	• Significant patellofemoral and/or medial osteoarthritis

and estimated blood loss. At discharge, patient distance walked and pain score was collected. Substantial clinical benefit (SCB) and minimal clinically improvement difference (MCID) threshold used for KOOS scoring was 20 and 14, respectively.[16] WOMAC MCID threshold used was 10.[17] Threshold used for patient acceptable symptom state (PASS) for the FJS score was 40.63.[18]

Descriptive statistical analysis and student t-tests of demographics and patient recorded outcome scores was performed on Microsoft Excel Version 16.16 (Microsoft Inc., Redmond, WA). Kaplan-Meier survivorship was calculated using GraphPad Prism 8.0.0 (GraphPad Software Inc., San Diego, CA).

Results

Mean last follow up was 5.1 ± 0.1 years. Mean age and BMI was 70.9 ± 7.2 years (range, 50.6–84.8) and 29.0 ± 4.2 kg/m^2 (range, 23.3–38.5), respectively. Intraoperatively, mean tourniquet time was 35.8 ± 6.7 min (range, 26.0–55.0), mean total operating room time was 110.0 ± 25 (range, 84.0–203.0), and mean estimated blood loss was 9.8 ± 8.8 mL (range, 0–30). At discharge, mean distance walked was 273.4 ± 70.4 feet (range, 80–500), and mean pain score was 2.0 ± 2.5 (range, 0–8).

Preoperative mean KOOS and WOMAC were 44.9 ± 12.3 (range, 25.0–80.0) and 26.6 ± 12.7 (range, 0.0–44.0). At 2-year follow up, mean KOOS, WOMAC, and FJS were 75.1 ± 13.5 (range, 40.6–95.0), 15.0 ± 7.2 (range, 0.0–29.0), and 81.0 ± 23.3 (range, 4.2–100), respectively. At five-year follow up, mean KOOS, WOMAC, and FJS were 75.3 ± 14.6 (range, 46.3–100.0), 14.9 ± 5.0 (range, 7.0–30.0), and 75.8 ± 27.4 (range, 10.4–100), respectively. Mean change from preoperative to postoperative in KOOS and WOMAC were 35.6 ± 27.1 and 11.7 ± 13.4 ($p < .001$ and $p < .001$) (Table 2). At five-year follow-up, 94% of patients were very satisfied/satisfied, 3% neutral, and 3% dissatisfied. 91% met activity expectations, 59% were more active than before, and 88% were walking without support. At final follow-up, 100% of patients returned to driving at mean 17.1 ± 11.7 days (range, 4.0–41.0). Survivorship was 100% at 5 years with no revisions or conversions to total knee arthroplasty. No patients were lost to follow up.

Discussion

Given the concerns surrounding lateral UKA, the purpose of this study was to assess the clinical and patient recorded outcome measures at mid-term follow up of a single center's experience with lateral RA-UKA. We found positive and significant improvement in, excellent survivorship and high patient satisfaction with lateral RA-UKA. This confirmed out hypothesis that lateral RA-UKA would be a successful surgery for addressing lateral compartment osteoarthritis.

Our finding of positive postoperative PROMs and significant improvement from preoperative values with lateral RA-UKA is in accordance with previous reports on RA-UKA. Burger et al. recently reported on 171 lateral RA-UKA and similarly found good to excellent KOOS scores with a mean of 85.6 at mean 4.3 years follow-up.[19] At shorter follow up, Zambianchi et al. also found good to excellent KOOS scores with a mean of 87.0 and a mean change of 54.0 in a cohort of 67 lateral RA-UKA at mean 36.3 months follow up.[11] They also reported a FJS score of 85.1 which is similar to our value (81) at short-term follow up at 2 years. Good PROM results are also seen at midterm follow up in conventional lateral UKA.[20] Our results are similar to the KOOS, WOMAC, and FJS scores reported for conventional lateral UKA.[21,22] It is also important to note that both our WOMAC and KOOS reached SCB and MCID therefore the improvement in PROM results have clinical impact. Similarly, our reported FJS score was above the recently published PASS threshold for UKA indicating successful resolution or acceptable symptom levels in our cohort.[18]

Lateral RA-UKA in our cohort had excellent survivorship with no knees requiring revision surgery or conversion to TKA. Excellent survivorship is seen in the literature with Burger et al. reporting 98.2% survivorship at mean 5 years and Zambianchi et al. reporting 100% at mean 3 year follow

Table 2. Patient recorded outcome measures of lateral robotic-arm assisted UKA.

	Preoperative (baseline)	2 Year	5 Year	Change from Baseline	P-value[a]
KOOS	44.9 ± 12.3	75.1 ± 13.5	75.3 ± 14.6	35.6 ± 27.1	< 0.001
WOMAC	26.6 ± 12.7	15.0 ± 7.2	14.9 ± 5.0	11.7 ± 13.4	< 0.001
FJS	—	27.7 ± 23.5	27.7 ± 27.6	—	

UKA, unicompartmental knee arthroplasty; KOOS, Knee injury Osteoarthritis Outcome Score; WOMAC, Western Ontario and McMaster Universities Osteoarthritis Score; FJS, Forgotten Joint Score.
[a]comparison between 5-year and pre-operative outcome scores.

up for lateral RA-UKA.[11,19] Burger et al. had three revisions at 1.6 years after the index surgery due to infection, aseptic loosening, and pain which were all revised to TKA.[19] Excellent survivorship at 5 year follow up is also seen in conventional UKA as reported by multiple studies.[15,23,24] Recent systematic reviews reported mean 90% survivorship[20] and 93% survivorship[25] after conventional lateral UKA at 5 year follow up. Despite the more challenging nature of the surgery, lateral UKAs have overall excellent survivorship.

The impact of robotic assistance in UKA compared to conventional UKA has not been fully determined for lateral UKA. Fewer revisions at 3 years follow up are reported amongst RA-UKA in registry data in comparison to conventional UKA with only 2.8% of RA-UKA requiring revision surgery.[2] This indicates that robotic assistance could play a role in further improving survivorship of UKA. The use of a computer navigation system in UKA has been shown to restore native kinematics specifically in lateral UKA while it did not for medial UKA.[26] This report indicates robotic assistance could provide advantages specifically for lateral UKA. Additionally, these RA-UKA systems have been shown to have greater reliability and accuracy in component placement in comparison to conventional UKA.[27,28] The advantages of the RA-UKA in conjunction with proper patient selection by an experienced surgeon likely contributes to the excellent survivorship seen in our study. More research is likely needed directly comparing RA-UKA and conventional UKA for lateral osteoarthritis.

Our study reported low estimated blood loss and high patient satisfaction with RA-UKA which are better than historical values for TKA. The decision to treat with RA-UKA versus TKA is still unclear as advantages exist for both options. We found our blood loss to be minimal and much less in comparison to commonly accepted numbers for perioperative blood loss in TKA of 0.5 L–1.5 L.[29,30] Additionally, RA-UKA had a higher patient satisfaction percentage compared to 82%–89% satisfaction seen historically in TKA patients.[31] Van der List et al. found superior short term functional outcomes for patients with isolated lateral osteoarthritis treated with RA-UKA versus TKA indicating RA-UKA has intraoperative and postoperative advantages specifically for patients with lateral osteoarthritis.[32] More research is needed assessing the long term outcomes comparing the two surgeries and perioperative factors impacting patient satisfaction postoperatively.

The present study has limitations. First, our sample size is relatively small which contributes to our excellent results and limits the generalizability. This is due to the low incidence of lateral osteoarthritis. However, our study has an advantage of only reporting lateral UKA results as this patient population tends to be different than those undergoing medial UKA. Future multicenter studies may be needed to better assess lateral UKA outcomes. The senior authors are very experienced with RA-UKA therefore patient selection and surgical technique are most likely optimized. Further studies are needed to see whether these results are reproducible for a less experienced surgeon. Additionally, while the results are positive, there is no conventional UKA comparison cohort therefore conclusions regarding the use of RA-UKA versus conventional UKA are outside the scope of this study.

Conclusions

In this study, lateral compartment RA-UKA demonstrated significantly improved clinical outcomes, high patient satisfaction, and excellent functional recovery at midterm follow up. Survivorship was excellent. Comparative studies are needed to determine differences between robotic-assisted and conventional lateral UKA, as well as comparisons to total knee arthroplasty populations.

Declaration of conflicting interests

The author(s) declared the following potential conflicts of interest with respect to the research, authorship, and/or publication of this article: Authors have received financial support. Full author disclosures available at AAOS website.

Funding

The author(s) received no financial support for the research, authorship, and/or publication of this article.

Ethical approval

This study was IRB approved by the host institution

Informed consent

Written consent provided.

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