Isolated Lateral Tibiofemoral Compartment Osteoarthritis

Survivorship and Patient Acceptable Symptom State After Lateral Fixed-Bearing Unicompartmental Knee Arthroplasty at Mean 10-Year Follow-up

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Background: Lateral unicompartmental knee arthroplasty (UKA) is an excellent option to alleviate disability and restore function in patients with lateral compartment knee osteoarthritis (OA). The purpose of the present study was to determine the survivorship and long-term outcomes in both younger/middle-aged and older patients with lateral compartment OA following non-robotically-assisted, fixed-bearing lateral UKA and to determine if an acceptable symptom state can be achieved.

Methods: All patients were managed with fixed-bearing lateral UKA by a single surgeon utilizing a lateral parapatellar approach without robotic assistance. The primary outcome variables were the Knee injury and Osteoarthritis Outcome Score (KOOS) Activities of Daily Living (ADL) and Sport subscale scores. In addition, the other KOOS subscores, the Lysholm score, the achievement of the Patient Acceptable Symptom State (PASS), and the Veterans RAND (VR-12) Physical Component Summary score (PCS) and Mental Component Summary score (MCS) were collected. Failure was defined as conversion to total knee arthroplasty (TKA). Patients were divided into 2 cohorts: younger/middle-aged patients (<60 years of age) and older patients (≥60 years of age).

Results: A cohort of 256 patients underwent medial (n = 193) or lateral (n = 63) UKA. Sixty-one patients met the inclusion criteria. At mean of 10 years (range, 4 to 17 years) of follow-up, there were no significant differences between the groups in terms of any patient-reported outcome measures ($p > 0.05$). The percentage of patients in whom PASS was achieved on the KOOS ADL and Sport subscores was 82% and 88%, respectively, in the younger cohort and 80% and 80%, respectively, in the older cohort. The mean survival estimate of the prothesis was 15.3 years (95% confidence interval [CI], 14.5 to 16.2 years) for the entire cohort. The estimated rate of implant survival in the younger cohort was 100% at 5 and 10 years, and the estimated rate of implant survival in the older cohort was 98% at 5 years and 96% at 10 years.

Conclusions: Lateral fixed-bearing, non-robotic UKA for the treatment of isolated lateral compartment OA resulted in >80% of patients reaching an acceptable symptom state in terms of both activities of daily living and sporting activities. UKA provides an excellent option that provides longevity with high PASS rates and return to activities with a low risk of complications and failure.

Level of Evidence: Therapeutic Level III. See Instructions for Authors for a complete description of levels of evidence.

Knee osteoarthritis (OA) is estimated to afflict 15 million individuals in the U.S., with 8.6 million having advanced symptomatic knee OA pain[1]. Persons <45 years of age make up nearly 2 million of this total, and persons between 45 and 64 years of age make up 6 million[1]. Fifty percent of these patients are known to have disease pathology that is isolated to a single, predominantly medial, compartment[2]. Lateral compartment OA, while seen in a smaller percentage of the population, is often ignored but exists as a symptomatic disease-causing disability similar to isolated medial compartment OA[2].

Valgus malalignment often shifts the weight-bearing load to the lateral compartment, predisposing the lateral aspect of the joint to isolated degeneration[3,4]. In a seminal study by Sharma et al., patients with valgus malalignment had a fivefold

Disclosure: The **Disclosure of Potential Conflicts of Interest** forms are provided with the online version of the article (http://links.lww.com/JBJS/H120).

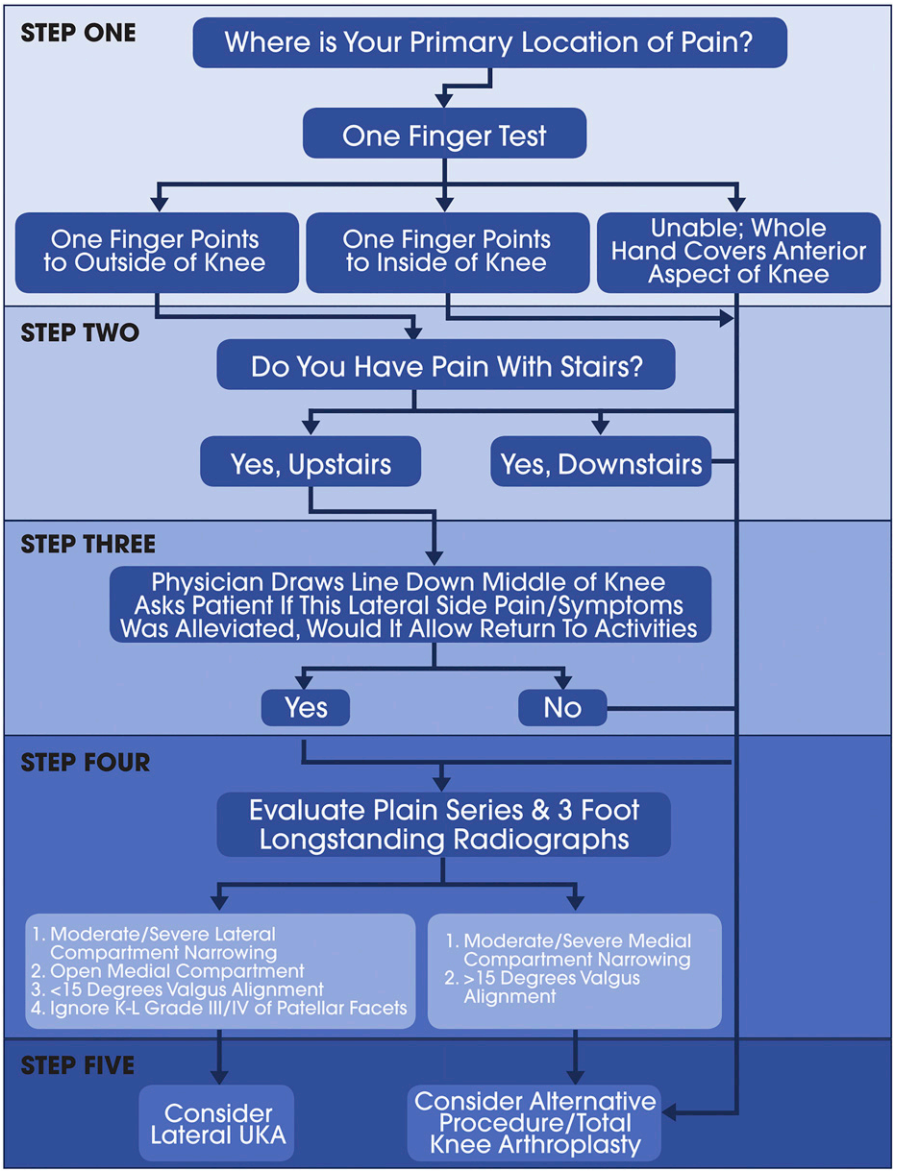

Fig. 1

Patient selection algorithm for lateral UKA. K-L = Kellgren-Lawrence.

increase in progression of lateral OA[3]. Treatment options for isolated lateral compartment OA in patients <60 years of age more commonly include cartilage procedures, meniscal transplants, and femoral osteotomies[5-10]; however, these options can be less favorable because of limited longevity, restriction of activities and sports participation[5,7,9-11], and complications such as infection, venous thromboembolism, fracture, delayed union or nonunion, and implant failure[6,8].

Lateral unicompartmental arthroplasty (UKA) is a treatment option for patients with isolated lateral compartment OA. Patients <60 years of age often present after a failed lateral meniscectomy or cartilage repair procedure, whereas patients ≥60 years of age present with idiopathic isolated lateral compartment OA[12,13]. These 2 cohorts have disparate expectations with younger patients desiring to return to sporting activities and older patients who may simply desire to return to activities of daily living (ADL) and recreational activities[14,15]. To our knowledge, there is limited literature that compares outcomes, return to sport, and patient expectations between these 2 distinct age groups with isolated lateral compartment OA.

The purpose of the present study was to determine the proportion of patients who achieved an acceptable level of function (Patient Acceptable Symptom State, PASS) at long-term follow-up after non-robotically-assisted, fixed-bearing lateral UKA. We hypothesized that younger patients would return to activities, including cutting and pivoting activities without restrictions, while older patients would resume ADL without the need to undergo a total knee arthroplasty (TKA).

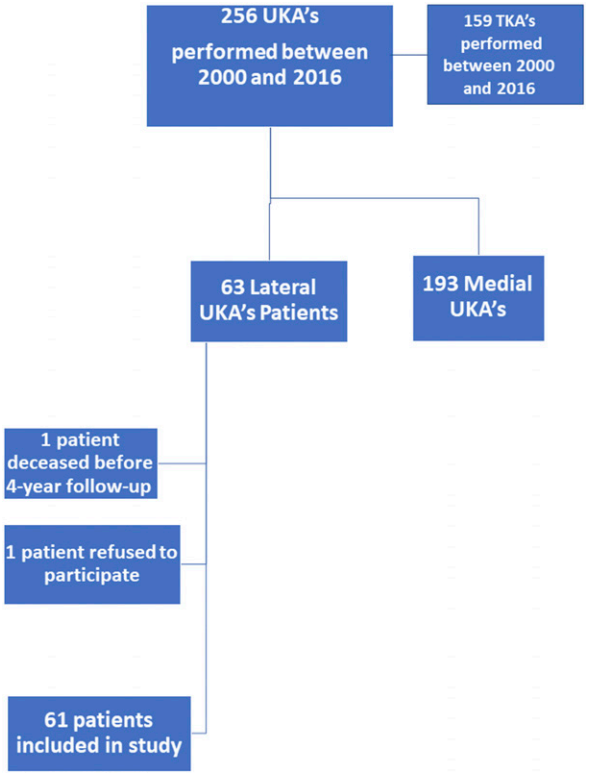

Fig. 2
Diagram showing patient selection for the study.

Materials and Methods

All patients who had been managed with lateral fixed-bearing UKA for the treatment of isolated lateral tibiofemoral compartment OA by the senior author from 2000 to 2016 were identified with use of a quality-assessment database. Patients were excluded if they declined to participate or were deceased before the time of the 4-year follow-up. The Zimmer Unicompartmental High Flex Knee System (ZUK; Smith & Nephew) was implanted in all knees, without robotic assistance, with use of a lateral parapatellar approach[16].

Patient selection criteria for lateral UKA were based on a treatment algorithm devised by the senior author (Fig. 1) and the revised criteria and surgical technique as previously described[16] (see Appendix). A body mass index (BMI) of >40 kg/m^2 was considered to be a contraindication for UKA. All patients required a flexion range of motion of at least 95°. A correctable flexion contracture of up to 5° with limited anterior subluxation on the lateral extension radiograph was considered to be acceptable. Tibial pseudosubluxation could also not be present on the anteroposterior standing radiograph. Varus stability at 0° and 30° had to be present with no more than 8 mm of excursion with a firm end point. All patients with a fixed valgus deformity of >15°, a fixed flexion contracture of >15°, or previous proximal tibial osteotomy and/or medial or tricompartmental OA were excluded. Patellofemoral arthritis, including Kellgren-Lawrence grade-4 involvement of the lateral facet, was not a contraindication, although every patient underwent a patelloplasty at the time of UKA.

Physical examination included knee flexion and extension range of motion and stability testing (e.g., Lachman, pivot shift, and varus/valgus). Examinations were performed by an independent examiner at the time of follow-up. Radiographic evaluation included a routine knee series (anteroposterior, Rosenberg, lateral, and Merchant views) and 3-foot (0.9-m)-long standing radiographs to assess limb alignment, the status of the medial and lateral tibiofemoral compartments, and the status of the prosthesis. Failure was defined as conversion to TKA. This study was approved by the institutional review board.

The hip-knee-ankle angle (HKAA) was used to measure limb alignment on 3-foot-long standing radiographs. The HKAA is the angle of intersection of a line drawn from the center of the femoral head through the midpoint between the femoral condyles and a line drawn from the center of the talus through the midpoint between the tibial spines[17].

Posterior tibial slope was measured preoperatively, and posterior slope of the implant was measured within 3 months after surgery, on lateral radiographs as previously described[18]. A positive value indicates a posterior tibial slope or posterior-sloping implant, and a negative value indicates an anterior tibial slope or anterior-sloping implant. All radiographic measurements were completed by an independent examiner.

Patient-Reported Outcome Measures

Patient-reported outcome measures included the Knee injury and Osteoarthritis Outcome Score (KOOS) subscales of Pain, Symptoms, ADL, Quality of Life (QoL), and Sport, as well as Lysholm, Tegner, and Veterans RAND (VR)-12 Physical

TABLE I Demographic Data for Patients <60 and ≥60 Years of Age

	<60 Years of Age (N = 18)	≥60 Years of Age (N = 43)	P Value
Age* *(yr)*	50.8 ± 4.5	73.5 ± 6.3	<0.001
Female:male ratio *(no. of patients)*	7:11	33:10	0.005
BMI* *(kg/m^2)*	27.5 ± 5	26.4 ± 4	0.55

*The values are given as the mean and standard deviation.

TABLE II Preoperative and Postoperative Physical and Radiographic Findings for Patients <60 and ≥60 Years of Age*

	<60 Years of Age (N = 18)	≥60 Years of Age (N = 43)	P Value
Posterior tibial slope *(deg)*	6.3 ± 2	6.9 ± 3.4	0.58
HKAA alignment			
Preoperative *(deg)*	2.5 ± 1.4 valgus	3.2 ± 1.7 valgus	0.10
Postoperative *(deg)*	1.4 ± 0.9 valgus	1.6 ± 1.0 valgus	0.52
Extension range of motion			
Preoperative *(deg)*	1.8 ± 4.4 (0 to 15)	2.7 ± 5 (−5 to 15)	0.67
Postoperative *(deg)*	0.5 ± 2.6 (−3 to 5)	0.1 ± 1.7 (−3 to 5)	0.52
Flexion range of motion			
Preoperative *(deg)*	120 ± 19 (70 to 135)	120 ± 11 (95 to 135)	0.91
Postoperative *(deg)*	130 ± 6 (116 to 140)	130 ± 10 (100 to 145)	0.98

*The values are given as the mean and standard deviation, with or without the range in parentheses. HKAA = hip-knee-ankle angle.

Component Summary score (PCS) and Mental Component Summary score (MCS). The primary outcome measures were the KOOS ADL and Sport subscores. To define successful outcomes in this study, the PASS was used for the KOOS subscores[19]. The KOOS PASS thresholds used following TKA were 87.5 for ADL, 87 for Pain, 84 for Symptoms, 66 for QoL, and 43.8 for Sport[20]. The Lysholm PASS threshold was 70 as previously reported following cartilage repair[21].

Statistical Analysis

Data are presented as the mean and the standard deviation. Age demonstrated a bimodal distribution; therefore, patients were separated into 2 groups for data analysis. The younger/middle-aged group comprised patients <60 years of age, and the older group comprised patients ≥60 years of age.

A 1-sample Kolmogorov-Smirnov test was used to test whether variables were normally distributed. The nonparametric Mann-Whitney U test was used to compare variables that were not normally distributed. The Spearman ρ correlation coefficient was used to assess associations between continuous variables. Conversion to TKA was used as the end point for survivorship. The Kaplan-Meier survivorship curve was used to estimate the probability of failure at a particular time point and accounted for patients who had not reached future time points at the time of the analysis.

Source of Funding

No external funding was received for this study.

Results

Of the 256 UKAs (193 medial UKAs and 63 lateral UKAs), 61 lateral UKAs met the inclusion criteria (Fig. 2). Demographics for both the younger/middle-aged and older groups are presented in Table I. Patients in the younger/middle-aged group were more likely to be male than female (p = 0.005; odds ratio [OR] = 5.2 [95% confidence interval (CI), 1.6 to 16.9]).

Radiographic measurements and knee range of motion are shown in Table II.

No superficial or deep infections were reported in any patient as defined by the Centers for Disease Control and Prevention (CDC) guidelines[21]. Three (4.9%) of the 61 patients required conversion to TKA at 6 months, 6 years, and 12 years (Table III). All 3 patients who had conversion to TKA were in the older group. The mean estimated prosthesis survival time for the lateral UKA cohort was 15.3 years (95% CI, 14.5 to 16.2 years). The prosthesis survivorship for the patients in the younger group was 100% at 5 and 10 years (Fig. 3). The prosthesis survivorship for patients in the older group was 98% at 5 years and 96% at 10 years. BMI and sex were not related to survival.

TABLE III Characteristics of Patients Who Underwent Conversion to Total Knee Arthroplasty

Patient	Age at UKA *(yr)*	Interval Between UKA and TKA	Age at TKA *(yr)*	Sex	BMI *(kg/m²)*	Postoperative Alignment	Postoperative Posterior Tibial Slope	Reason for Failure
1*	73	6 months	74	F	28.4	3° varus	7°	Overstuffed lateral compartment
2	70	6 years	76	F	27	3° valgus	5°	Traumatic fall
3	62	12 years	74	M	28.7	3° valgus	7°	Skiing accident

*This patient was one of the first 5 of the surgeon's series.

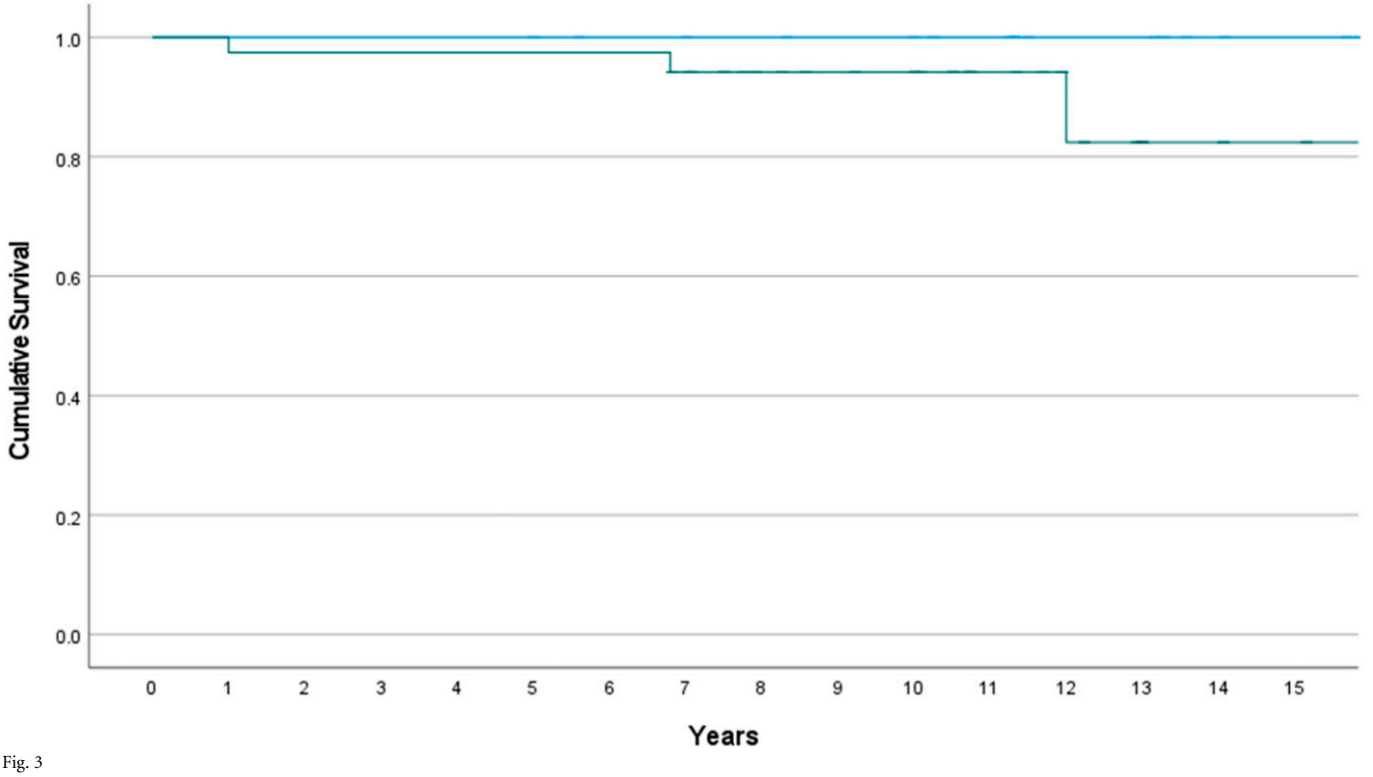

Fig. 3

Kaplan-Meier survivorship curve of the younger/middle-aged (<60 years of age) (blue line) and the older group (≥60 years of age) (green line) of patients managed with lateral UKA.

Patients were evaluated and outcomes scores were measured at a mean of 10 ± 3 years (range, 4 to 17 years). Patient-reported outcomes are shown in Table IV. There were no significant differences between the younger and older groups at the time of the latest follow-up ($p > 0.05$ for all). The median Tegner activity score was 6 (range, 4 to 10) in patients in the younger group and 3 (range, 2 to 8) in the older group ($p = 0.002$).

In the younger group, the PASS was achieved for 82% of patients for the KOOS ADL subscore and 88% for the KOOS Sport subscore. In the older group, the PASS was achieved for 80% of patients for the KOOS ADL subscore and 80% for the

TABLE IV Patient-Reported Outcome Measures at Latest Follow-up in Patients <60 and ≥60 Years of Age*†

	<60 Years of Age (N = 18)‡	≥60 Years of Age (N = 40)‡	P Value
Follow-up *(yr)*	11 ± 3	10 ± 3	0.28
VR-12			
MCS	52 ± 6	53 ± 7	0.68
PCS	55 ± 9	52 ± 9	0.26
KOOS			
Pain	91 ± 15	92 ± 10	0.28
Symptoms	80 ± 16	79 ± 17	0.52
ADL	92 ± 14	90 ± 10	0.88
Sport	82 ± 29	70 ± 22	0.40
QoL	86 ± 18	84 ± 17	0.53
Lysholm	90 ± 13	87 ± 18	0.94

*The primary outcome variables were KOOS ADL and KOOS Sport subscores. The values are given as the mean and standard deviation. †MCS = Mental Component Summary score, PCS = Physical Component Summary score, KOOS = Knee injury and Osteoarthritis Outcome Score, ADL = activities of daily living, QoL = quality of life. ‡Includes patients who did not have conversion to total knee arthroplasty.

KOOS Sport subscore. PASS scores for all KOOS subscores are shown in Figure 4. The mean Lysholm score at the time of follow-up was 90 in the younger group in this study, compared with 70 to 82 in patients following cartilage procedures as reported in previous studies[9,10].

Discussion

Lateral UKA for the treatment of isolated lateral compartment OA is an excellent option to alleviate pain and restore function in patients <60 years of age as well as those ≥60 years of age. In the present study, we noted 100% survivorship of the ZUK prothesis in patients <60 years of age and 96% survivorship in patients ≥60 years of age at mean of 10 years of follow-up. Eighty percent of the patients in the younger group reached the PASS for the KOOS ADL subscore. The proportion of patients that achieved PASS surpassed those reported for TKA by a large margin[22-24]. Our cohort of patients <60 years of age had a median Tegner score of 6 at the time of the latest follow-up. These patients reported active participation in singles tennis, downhill skiing, and pivoting sports, including soccer and hockey. The cohort of patients ≥60 years of age had a median Tegner score of 3 that allowed them to return to all of their activities of daily living.

Survivorship following a lateral UKA is variable in the literature, with rates ranging from 74.5% to 100% at 2 to 15 years of follow-up[25-35]. van der List et al. reported that lateral UKAs were associated with a survivorship rate of 93.2% at 5 years, 91.4% at 10 years, and 89.4% at 15 years[33]. Baker et al., with use of data from the National Joint Registry for England, Wales, Northern Ireland and the Isle of Man, noted survivorship of 93% at 5 years for both medial and lateral UKA[36]. A recent systematic review showed higher survivorship rates in cohort studies (91% at 10 years) as compared with most registry studies (84% at 10 years)[35]. Registry data often combine both medial and lateral UKA as well as fixed and mobile-bearing implants, which may explain some of the disparity in the literature. Registry data often include procedures performed by less-experienced and low-volume surgeons (i.e., those who perform <10 UKAs per year), which may also skew the data[37].

In the present study, our younger cohort (i.e., those who underwent lateral TKA at an age of <60 years) had 100% long-term survivorship and restoration of function including vigorous sport activities as demonstrated by the KOOS Sport subscore. Patients in that cohort (mean age, 50.8 years) exhibited superior outcomes compared with those reported after many cartilage procedures[9,10]. Gille et al. reported on outcomes following autologous matrix-induced chondrogenesis (AMIC) after a mean duration of follow-up of 4.5 years[9]. The mean Lysholm score at 5 years was 80.6 ± 22.3 in patients >46 years of age. Ossendorff et al., in a study of patients who were followed for 10 years after autologous chondrocyte implantation, reported a mean Lysholm score of 71 ± 18 at the time of follow-up[10]. In the present study, the mean Lysholm score for the entire cohort of patients who underwent lateral UKA was 89 at a mean of 10 years.

Meniscal allografting, an alternative treatment for isolated lateral compartment knee pain, has shown positive results; however, outcomes and survivorship are dependent on the severity of arthritis and the age of the patient[11]. van der Wal et al. reported a decline in mean KOOS ADL and Sport subscores over time, with scores of <60 between 2 and 4 years and scores of <40 by year 6[11]. In our cohort of patients who were managed with lateral UKA, the KOOS ADL subscore was 91 and the KOOS Sport subscore was ≥70 at mean of 10 years of follow-up.

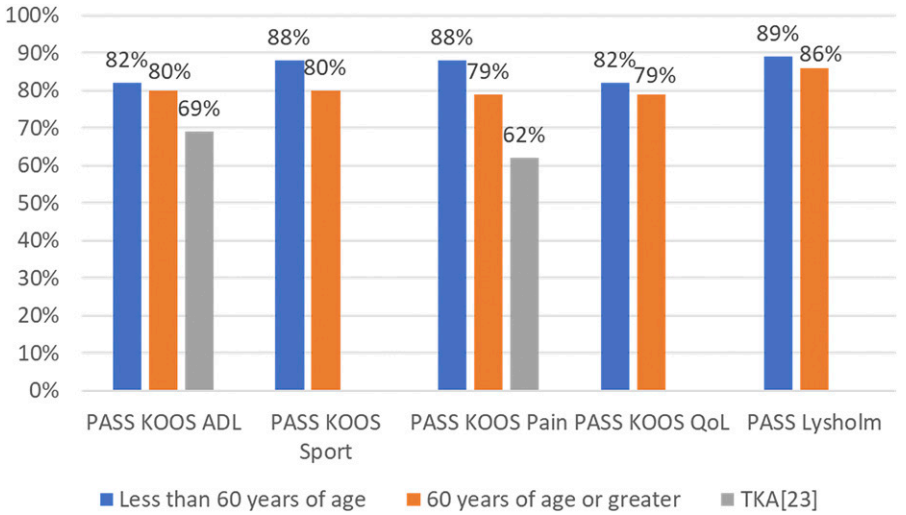

Fig. 4

Graph showing the percentage of patients reaching the Patient Acceptable Symptom State (PASS) for KOOS subscores, comparing younger (<60 years of age) and older patients (≥60 years of age). After TKA in previous studies, 69% of patients reached the PASS for the KOOS ADL subscore and 62% for the KOOS Pain subscore[22,23].

Distal femoral and medial tibial closing-wedge osteotomies are 2 additional options for the treatment of lateral compartment knee pain that have been associated with limited long-term success. Backstein et al. reported a 10-year survival rate of 82% in patients with distal femoral varus osteotomy, with good to excellent results in only 60% of patients[38]. Mathews et al. reported a 36% rate of satisfactory results at 1 to 8 years follow-up, with 19% of patients requiring conversion to TKA within 5 years, after a medial tibial closing-wedge osteotomy[6]. Complication rates for these osteotomies have been reported to be as high as 57%[8]. Complications have included severe knee stiffness, nonunion or delayed union, infection, and failure of fixation[8]. None of these reported complications for osteotomies were seen in our series of lateral UKA.

TKA is commonly performed in patients >60 years of age. Aletto et al., in a study of 200 TKA procedures in patients with a mean age of 64 years, reported a mean Lysholm score of 71.4 at the time of follow-up[39]. Başdelioğlu, in a study of 588 patients who underwent TKA, reported Lysholm scores ranging from 71 to 79 and KOOS scores ranging from 71 to 79 after 10 years of follow-up[40]. In our cohort, at a mean of 10 years following lateral UKA, the Lysholm score was 87 and the KOOS ADL subscore was 91 for patients who were ≥60 years at the time of the procedure. These findings, combined with the commonly reported 19% dissatisfaction rate following TKA[40], may encourage surgeons to consider lateral UKA as an alternative to TKA in older patients with single-compartment (lateral) OA.

Lateral UKA is a technically demanding procedure. Reproducing the biomechanics of the "screw-home mechanism" of the lateral compartment is essential. This biomechanical "screw-home mechanism" of external rotation of the tibia between 20° of knee flexion and full extension results in locking of the knee, providing maximum stability when standing erect. Positioning the knee in flexion when placing the components exaggerates this rotation to accommodate this "screw-home mechanism."

Limitations

Our single-surgeon study is not without limitations, including a potential lack of generalizability. Including additional surgeons would have added variability. Our results may be relevant to medium-volume surgeons, who represents the majority of orthopaedic surgeons performing this procedure as noted previously by Liddle et al.[37]. The need for education and training to refine a surgeon's familiarity with this procedure is essential. We recommend that surgeons utilize a bioskills laboratory and consider operating with an experienced surgeon when performing their first 10 lateral UKAs.

Our cohort was a consecutive series of patients who were managed with lateral UKA by the same surgeon; no other UKA implants were used by this surgeon during the study period. The small cohort (n = 9) of patients with a BMI of 30 to 40 kg/m^2 had similar longevity and PASS achievement rates as those with a BMI of <30 kg/m^2. This small group within our patient population needs further investigation to determine the wide applicability of lateral UKA. This study is strengthened by the length of follow-up, the inclusion of clinical outcome follow-up data and rates of PASS achievement for the KOOS ADL and Sport subscores, and the high internal validity due to a single-surgeon design.

Conclusions

Lateral fixed-bearing UKA for isolated lateral compartment OA results in a majority of patients reaching an acceptable symptom state for both activities of daily living and sporting activities as determined by the KOOS, regardless of age, at a mean 10-year follow-up. No patient in the younger group, less than 60 years of age, underwent conversion to TKA. In patients with isolated lateral compartment OA, lateral UKA may provide longevity with high PASS achievement rates, return younger patients to their choice of pivoting sport, and return older patients to ADLs, with a low risk of complications and conversion to TKA in the long term.

Appendix

eA Supporting material provided by the authors is posted with the online version of this article as a data supplement at jbjs.org (http://links.lww.com/JBJS/H121). ■

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