

No Significant Difference in Short-Term Results between Mobile-Bearing and Fixed- Bearing Unicompartmental knee arthroplasty for Medial Osteoarthritis: A Randomized Controlled Trial in a Chinese Cohort

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Abstract

Objective

To compare short-term outcomes of mobile-bearing (MB) and fixed-bearing (FB) unicompartmental knee arthroplasty (UKA) in Chinese patients with medial knee osteoarthritis (KOA).

Methods

This prospective randomized trial enrolled 124 patients (Kellgren-Lawrence grade 3–4) at Tongji University-affiliated Yangpu Hospital (2021–2022), randomized to MB-UKA (Oxford prosthesis, n = 62) or FB-UKA (St Georg Sled prosthesis, n = 62). Primary outcomes were Oxford Knee Score (OKS) and Forgotten Joint Score (FJS); secondary outcomes included pain (VAS), range of motion (ROM), and femorotibial angle (FTA). Safety and prosthesis survival were assessed over 3-year follow-up.

Results

Baseline characteristics were balanced. Both groups showed sustained improvements in OKS, VAS, and ROM. The MB group had superior OKS only at 12 months ($P = 0.006$), with no intergroup differences thereafter. FJS, ROM, and FTA were comparable. The MB group had higher venous thrombosis and persistent pain rates; the FB group had more transient nerve injuries. Prosthesis survival did not differ.

Conclusion

MB-UKA and FB-UKA yield comparable short-term efficacy in Chinese patients with medial KOA. Prosthesis selection should consider safety profiles, patient factors, and cost.

The Chinese Clinical Trial Registry : ChiCTR2100051230; PID: 133739; Reg Date: 2021-09-16

Introduction

Knee Osteoarthritis (KOA) is a chronic joint disorder characterized by articular cartilage degeneration, involving subchondral bone and synovium[1, 2]. Unicompartmental Knee Arthroplasty (UKA) is an effective intervention for end-stage KOA, especially in isolated compartmental damage, offering advantages such as improved postoperative range of motion, accelerated functional recovery, better gait performance, and reduced complications[3]. The "minimally invasive UKA" concept has further expanded its clinical application[4].

Current UKA prostheses are mainly divided into Mobile Bearing (MB) and Fixed Bearing (FB) designs. MB prostheses consist of a spherical femoral component and a highly conforming polyethylene tibial insert, aligning with physiological structures[5]; their single-radius curvature facilitates coordination at large flexion angles and knee kinematic restoration, with theoretical benefits in joint congruence. The FB design, modified by Insall et al. in 1976, features multi-curvature femoral components and flat tibial components to better replicate physiological knee structures[6]. While long-term TKA revision studies

show no significant difference in survival rates between the two[7, 8], MB versus FB UKA remains clinically controversial—compounded by limited large-scale, high-quality randomized controlled trials in China, where UKA adoption is recent and underdeveloped. Existing comparative studies yield inconsistent findings on functional outcomes and survival rates[9]. Thus, this prospective randomized study aims to compare MB and FB UKA in clinical function scores, radiographic outcomes, and prosthesis survival, to identify safer and more effective treatment options and guide prosthesis selection for Chinese surgeons.

Materials and methods

1. Study Design

This prospective randomized controlled trial was conducted at the Joint Surgery Clinic, Department of Orthopedics, Yangpu District Central Hospital Affiliated to Tongji University School of Medicine. It was approved by the Ethics Committee of Yangpu Hospital, Tongji University (Approval No.: LL-2021-KY-004) in compliance with the Declaration of Helsinki, and registered in the Chinese Clinical Trial Registry (Registration No.: ChiCTR2100051230). All participants provided written informed consent after full verbal and written briefing. Randomization was performed via a computer-generated random sequence. A total of 279 eligible patients were recruited between September 2021 and September 2022. The study protocol, ethics approval, and related materials are available in the Supplemental File. This trial adhered to the CONSORT statement.

Eligible patients were aged ≥ 50 years with correctable knee varus deformity, knee flexion $\geq 90^\circ$, varus deformity $< 15^\circ$, flexion contracture $< 5^\circ$ [10], and medial compartment knee osteoarthritis (Kellgren-Lawrence grade 3–4)[11]. Exclusion criteria included multi-compartmental knee involvement, defective structure or function of the cruciate ligaments or collateral ligaments, history of knee trauma or intra-articular injection within 3 months prior to enrollment[12], previous fibular/tibial/femoral osteotomy, active infection, inflammatory arthritis, severe osteoporosis, other serious comorbidities, and non-residence in downtown Shanghai.

2. Surgical technique

All surgeries were performed by a single experienced joint surgeon with extensive expertise in UKA. During the procedures, the FB group received the St Georg Sled fixed platform prosthesis (Waldemar Link), while the MB group received the Oxford mobile platform prosthesis (Zimmer Biomet). Both groups underwent surgery using the same medial parapatellar incision and approach, following the standard surgical techniques designed for each prosthesis. The detailed surgical procedure and perioperative management are available in Supplemental File.

3. Data collection and follow-up study

Researchers collected preoperative patient data (name, age group, gender, BMI, affected side), medical history (hypertension, diabetes, coronary artery disease, etc.), affected knee range of motion (ROM, detailed measurement in Supplemental File 1), knee joint scores, and anteroposterior/lateral knee X-rays for pre- and postoperative improvement analysis. Patients underwent X-ray before discharge and regular follow-up (1, 3, 6, 12 months, 2, 3 years postoperatively) via outpatient visits and telephone consultations to assess satisfaction and rehabilitation progress, with home pain management guidance provided.

4. Outcome Measures

Primary efficacy outcomes include the Oxford Knee Score (OKS)[13] (assessing knee function and pain) and the Forgotten Joint Score (FJS)[14] (evaluating post-surgical satisfaction). Secondary efficacy outcomes comprise the Visual Analog Scale (VAS)[15] (pain intensity), knee range of motion, and knee femoral-tibial angle (FTA).

Safety analysis includes postoperative complications (wound dehiscence/infection, pain, prosthesis loosening, nerve injury, venous thromboembolism, and functional impairment) followed by assessment of prosthesis survival, which is defined by the necessity of UKA revision (attributed to periprosthetic joint infection[16], contralateral compartment osteoarthritis progression, periprosthetic fractures, aseptic loosening, or spacer dislocation) or patient mortality.

5. Statistical Analysis

Sample size calculation was based on a study evaluating the Forgotten Joint Score, which reported means (standard deviations [SDs]) of 70.0 (11.5) for the FB group and 76.6 (12.2) for the MB group[17]. Using PASS 15.0 software, a minimum of 52 participants per group was determined. Accounting for a 20% dropout rate, 65 participants per group were included.

Quantitative data were tested for normality. Normally distributed data (expressed as mean $\pm$ SD) were compared between groups using independent two-sample Student's *t*-tests. Non-normally distributed data (expressed as median [interquartile range, 25th–75th percentiles]) were analyzed with Wilcoxon rank-sum test. Categorical data were presented as frequencies and percentages, with comparisons using chi-square tests. A two-sided $P < 0.05$ was considered statistically significant. All analyses were performed using SPSS 26.0.

Results

1. Study Population and Baseline Characteristics

From September 2021 to September 2022, 279 patients meeting the inclusion criteria were screened for eligibility (Fig. 1). Ten patients were excluded due to meeting exclusion criteria, and 145 declined participation, resulting in a final enrollment of 124 patients (62 in the MB group and 62 in the FB group).

During follow-up, 19 patients were lost to follow-up, and the remaining patients completed the protocol-specified treatment and follow-up.

Baseline characteristics were well-balanced between the two groups, with the only significant difference observed in hospitalization costs ($P < 0.05$; Table 1). Demographically, gender distribution was identical (16 males, 46 females per group; $P = 1.000$), and no differences were noted in age stratification (51–60 years to > 80 years; $P = 0.507$), affected side (left/right; $P = 0.068$), body weight, height, or body mass index (BMI; all $P > 0.05$). Preoperative knee function and disease severity—assessed by knee range of motion (ROM), lower limb varus angle, Oxford Knee Score (OKS), and Visual Analog Scale (VAS) for pain—were comparable between groups (all $P > 0.05$). For health economics indicators, hospitalization duration did not differ ($P = 0.773$), but the FB group had significantly lower hospitalization costs than the MB group ($P < 0.001$).

Table 1
Study participant characteristics and baseline comparison of knee joint scores.

	MB group (n = 62)	FB group (n = 62)	P-value*
Sex (n)			
Male	16	16	1.000
Female	46	46	
Age (n)			
51–60	5	5	0.507
61–70	24	24	
71–80	29	26	
>80	4	7	
Affected Side (n)			
Left	24	19	0.068
Right	38	43	
Weight [kg, Median (IQR)]	68.00 (14.00)	65.00 (15.00)	0.750
Height [cm, Mean (SD)]	162.03 (7.47)	160.60 (7.85)	0.655
BMI [kg/m ² , Median (IQR)]	25.37 (5.00)	25.84 (6.00)	0.642
ROM [°, Median (IQR)]	102.00 (11.25)	101.00 (12.00)	0.197
Lower Limb Alignment [varus °, Median (IQR)]	8.50 (3.35)	7.90 (4.55)	0.472
OKS [Mean (SD)]	50.08 (3.06)	49.46 (2.72)	0.238
VAS [Median (IQR)]	6.00 (2.25)	5.00 (3.00)	0.766
Length of Hospital Stay [d, Median (IQR)]	7.00 (2.00)	7.00 (1.00)	0.773
Hospitalization Expenses [10k CNY, Median (IQR)]	6.90 (1.19)	6.06 (1.01)	0.000 #
* Wilcoxon rank-sum test, Chi-square test or t-tests was conducted as appropriate.			

2. Efficacy Outcomes

2.1 Primary Efficacy Outcomes

Postoperative OKS decreased over time in both groups, indicating sustained improvement in knee function (Table 2). The MB group demonstrated significantly better OKS outcomes only at 12 months postoperatively ($P = 0.006$); no between-group differences were observed at 1, 3, 6, 24, or 36 months (all $P > 0.05$). FJS used to evaluate post-surgical satisfaction and prosthesis “integration”—was comparable between groups at 1, 2, and 3 years postoperatively (all $P > 0.05$; Table 3), suggesting similar patient-reported acceptance of the prosthesis in both groups.

Table 2
Intergroup comparison of postoperative OKS scores.

OKS	MB group	FB group	P-value*
1 month [Mean (SD)]	37.00 (3.99)	36.93 (3.11)	0.539
3 month [Mean (SD)]	37.95 (3.79)	37.81 (3.63)	0.804
6 month [Median (IQR)]	28.00 (4.00)	27.00 (4.00)	0.155
12 month [Mean (SD)]	28.77 (4.30)	27.98 (2.96)	0.006 #
24 month [Mean (SD)]	26.30 (3.43)	25.79 (2.83)	0.097
36 month [Median (IQR)]	24.00 (2.25)	24.00 (2.00)	0.589#
* Wilcoxon rank-sum test or t-tests was conducted as appropriate.			

Table 3
Intergroup Comparison of FJS Scores postoperative

Median (IQR)	MB group	FB group	P-value*
1-years postoperative forgotten Joint Score [Median (IQR)]	72.90 (12.50)	70.71 (16.70)	0.738
2-years postoperative forgotten Joint Score [Median (IQR)]	72.90 (6.20)	70.80 (8.30)	0.633
3- years postoperative forgotten Joint Score [Mean (SD)]	74.87 (5.67)	73.46 (5.44)	0.638
* Wilcoxon rank-sum test or t-tests was conducted as appropriate.			

2.2 Secondary Efficacy Outcomes

Throughout the 36-month follow-up, VAS scores were comparable between groups (all $P > 0.05$; Table 4), reflecting equivalent pain relief efficacy. Both groups exhibited similar trends of pain reduction over time. Knee ROM and FTA did not differ between groups (all $P > 0.05$; Table 5), indicating similar prosthesis

positional stability and joint flexibility. Postoperative ROM improved from baseline (101–102°) to 118–123° in both groups across all time points.

Table 4
Between-group effects of postoperative VAS scores for MB and FB.

VAS	MB group	FB group	P-value*
1 month [Median (IQR)]	3.00 (2.00)	3.00 (2.00)	0.460
3 month [Median (IQR)]	3.00 (2.00)	3.00 (2.00)	0.979
6 month [Median (IQR)]	3.00 (1.00)	3.00 (2.00)	0.839
12 month [Median (IQR)]	3.00 (1.25)	3.00 (2.00)	0.874
24 month [Median (IQR)]	2.00 (1.00)	2.00 (1.00)	0.463
36 month [Median (IQR)]	2.00 (1.25)	2.00 (2.00)	0.175
* Wilcoxon rank-sum test.			

Table 5
Between-group comparison of postoperative lower limb alignment in the knee.

2-years postoperative lower limb alignment [varus °, Median (IQR)]	MB group	FB group	P-value*
	4.48 (3.23)	4.42 (2.58)	0.850
3-years postoperative lower limb alignment [varus °, Mean (SD)]	4.42 (2.75)	4.45 (2.92)	0.842
1-month postoperative range of motion [°, Median (IQR)]	102.50 (12.75)	104.00 (16.00)	0.900
3-months postoperative range of motion [°, Mean (SD)]	110.98 (7.50)	109.18 (8.79)	0.157
6-months postoperative range of motion [°, Median (IQR)]	120.00 (13.50)	118.50 (16.00)	0.789
1-year postoperative range of motion [°, Median (IQR)]	118.50 (13.00)	119.00 (15.25)	0.608
2-years postoperative range of motion [°, Median (IQR)]	119.50 (16.25)	119.50 (14.25)	0.727
3-years postoperative range of motion [°, Median (IQR)]	120.50 (14.25)	123.50 (17.25)	0.574
* Wilcoxon rank-sum test or t-tests was conducted as appropriate.			

2.3 Safety Analysis

Complication profiles varied by group (Table 6), The MB group had higher rates of lower extremity calf muscular venous thrombosis (10 vs. 4 cases) and postoperative persistent/exacerbated pain (7 vs. 3 cases), plus 1 unique case of spacer dislocation; no postoperative joint stiffness was reported in this group. The FB group had more transient nerve injuries (local hypoesthesia) (7 vs. 5 cases), 1 unique periprosthetic fracture andrequiring conversion to TKA, 1 case of postoperative joint stiffness, and 1 case of TKA performed at an outside institution due to persistent pain (none in the MB group). Wound infection was rare (MB: 1 case; FB: 2 cases). Neither group reported periprosthetic joint infection, contralateral compartment osteoarthritis progression, or aseptic loosening.

Table 6
Adverse Events.

No. of patients with adverse events	MB group	FB group
	17	15
No. of adverse events	24	18
Type of adverse event		
wound infection	1	2
Periprosthetic fracture or fracture		1
spacer dislocation.	1	
Lower Extremity (Calf Muscular Venous Thrombosis)	10	4
Postoperative Joint Stiffness		1
Postoperative persistent/exacerbated pain	7	3
Transient nerve injury (Local Hypoesthesia in the Surgical Area)	5	7
Revision surgery		
Component revision/change	1	
Conversion to total knee arthroplasty		2

Discussion

This single-center prospective randomized controlled trial systematically compared clinical outcomes of MB-UKA and FB-UKA for anteromedial osteoarthritis in Chinese patients. All procedures were performed by the same experienced senior surgical team (over 1,000 UKA cases of both types) following standardized protocols to minimize surgeon-related bias.

Both groups showed sustained postoperative functional improvement, consistent with prior literature[18]. Notably, the MB-UKA group had superior Oxford Knee Scores at 12 months, but this advantage diminished at 24–36 months—contrary to theoretical expectations[19, 20]. This may reflect

early functional adaptation facilitated by MB-UKA's structural conformity, with FB-UKA gradually matching performance via component stability. MB-UKA's kinematic advantages depend on precise tibial resection, prosthesis positioning, and soft tissue balancing[22, 23], linked to instrument adjustability[21]. The Forgotten Joint Score was similar between groups, indicating comparable subjective prosthesis integration, aligning with patient-reported outcome studies[24].

Regarding range of motion (ROM) and femorotibial angle (FTA), improvements were comparable between groups, with no significant intergroup differences—despite some reports of better MB-UKA ROM after propensity score matching[25]. This convergence may relate to mild physical activities (e.g., Tai Chi, square dancing) in elderly Chinese patients, attenuating prosthesis design-related advantages. Lower limb alignment and ligament tension changes may exert greater functional impacts than prosthesis type itself[26, 27].

For prosthesis survival (endpoint: revision/reoperation), one MB-UKA case underwent spacer exchange due to dislocation; the FB-UKA group had one periprosthetic fracture revision and one external total knee arthroplasty for persistent pain. Despite design differences (MB-UKA reduces polyethylene wear via mobile mechanics; FB-UKA controls load via fixed mechanics), survival rates did not differ statistically during follow-up. Prosthesis-related complications (dislocation, fracture, persistent pain) remain key reoperation causes, potentially associated with prosthesis type and patient-specific factors.

Complication profiles differed: MB-UKA had higher lower extremity venous thrombosis (10 vs. 4 cases) and persistent pain (7 vs. 3 cases), plus one spacer dislocation; FB-UKA had more transient nerve injuries (7 vs. 5 cases), one periprosthetic fracture, one joint stiffness, and one external total knee arthroplasty. Wound infection rates were low (1 vs. 2 cases), with no periprosthetic joint infection, contralateral compartment osteoarthritis progression, or aseptic loosening. These outcomes may reflect MB-UKA's sensitivity to soft tissue balance and technical precision[23], while FB-UKA complications relate to rigid fixation and osteotomy factors[26, 28].

Limitations include potential ROM measurement bias, reduced statistical power from external factor-affected sample size, and insufficient 3-year follow-up for long-term prosthesis durability. Future studies should extend follow-up, incorporate 3D motion analysis and finite element modeling to explore biomechanical characteristics, and optimize prosthesis selection and surgical strategies based on patient-specific factors to advance personalized treatment.

Conclusion

Both MB and FB UKA are viable for AMOA in Chinese patients, with no meaningful short-term efficacy differences. The transient 12-month OKS advantage of MB is unlikely to influence clinical decision-making as it does not translate to sustained benefits or improved patient-perceived integration. Prosthesis selection should be guided by design-specific safety profiles and patient factors: FB may be preferred for cost-sensitive patients or those at higher risk of alignment errors, avoiding MB's spacer dislocation risk, and is more forgiving for novice surgeons. The spacer dislocation risk in MB UKA

underscores the need for precise osteotomy and ligament balancing, extending the learning curve compared to FB. Ultimately, the success of UKA in clinical practice depends on the standardized implementation of core surgical techniques rather than prosthesis design alone.

Declarations

Ethics Approval and Consent to Participate

This randomized controlled trial was approved by the Institutional Review Board of Yangpu Hospital, Tongji University School of Medicine (approval number LL-2021-KY-004) and conducted in accordance with the ethical principles outlined in the Declaration of Helsinki. All eligible participants received comprehensive written and verbal counseling regarding trial procedures, surgical approaches, follow-up schedules, and foreseeable risks before enrollment. Written informed consent was obtained from every patient prior to randomization and operative intervention. All personal identifiers were removed from study datasets to preserve patient confidentiality.

Consent for Publication

No individual-level identifiable clinical data, photographs, or imaging records are included in this manuscript; therefore, specific written informed consent for publication from individual participants was not required.

Conflicts of Interest

All authors affirm no relevant financial or nonfinancial conflicts of interest. No author holds equity or institutional ties to implant, pharmaceutical, or device companies relevant to the present work.

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Author Contribution

Huaming Xue and Yihui Tu conceived and designed the trial, secured project funding, supervised study execution, and revised the final manuscript. Jiazhong Ji, Long Xue, and Tao Yang enrolled study subjects, completed clinical follow-up, and compiled raw clinical data. Wenzheng Zhang and Xuefeng Lei performed all statistical analyses and drafted the initial manuscript. Tong Ma and Tao Wen critically reviewed and revised manuscript content and verified study data integrity. All authors reviewed the completed manuscript and approved submission.

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Data Availability

Individual participant data generated during this trial are not publicly available to protect protected health information. Qualified investigators seeking access to source study data may submit a formal written request to the corresponding author (Huaming Xue, x11h22m33@126.com). Data access is contingent upon execution of a formal data-use confidentiality agreement.

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Figures

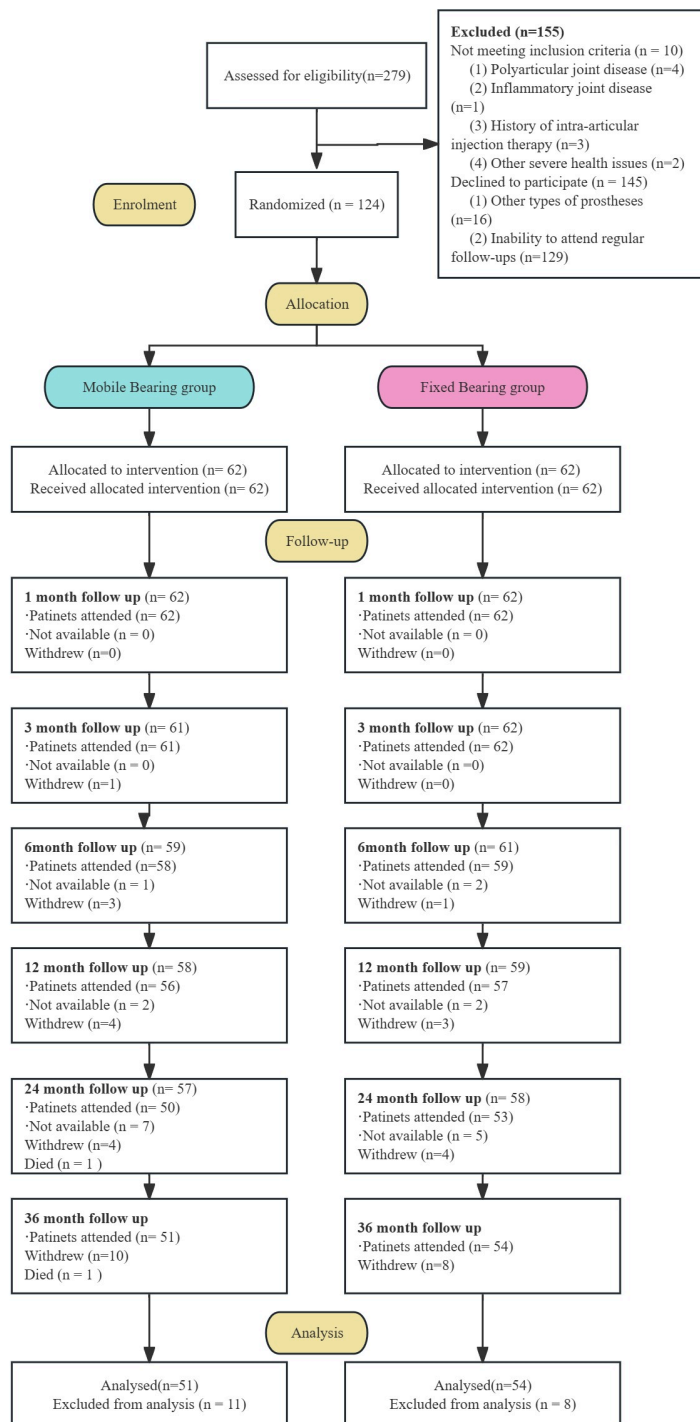


Figure 1. CONSORT flow diagram of patient enrollment, randomization, follow-up, and analysis

Figure 1

CONSORT flow diagram of patient enrollment, randomization, follow-up, and analysis.

Supplementary Files

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