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Early postoperative gait characteristics after unicompartmental knee arthroplasty: results and clinical implications

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Abstract

Background and objective Despite the established efficacy of unicompartmental knee arthroplasty (UKA), quantitative assessments of early postoperative changes in gait and stability remain limited. This study investigated preoperative and postoperative alterations in gait and stability following UKA.

Methods A cohort of 30 patients undergoing unilateral UKA at the Joint Surgery Department of the Affiliated Hospital of Xuzhou Medical University between May 2021 and 2022 was compared with a control group of 15 healthy elderly individuals without a history of hip or knee pathology. Evaluated parameters included Hospital for Special Surgery (HSS) scores, center of pressure path length, 95% confidence ellipse area, pace, stride length, stride frequency, gait cycle, and single support time percentage. Measurements were obtained preoperatively and at 1 and 3 months postoperatively for both groups.

Results Step frequency remained unchanged between preoperative and 1-month postoperative assessments ($p > 0.05$). Stability declined at 1 month postoperatively relative to baseline, whereas other gait parameters showed significant improvement ($p < 0.05$). By 3 months, HSS scores and all gait and stability metrics exhibited substantial enhancement compared to baseline ($p < 0.05$).

Conclusions Early gait recovery following UKA demonstrated a positive trajectory; however, step frequency showed minimal improvement, and stability remained compromised at 1 month postoperatively. Quantitative gait analysis provides a robust framework for monitoring rehabilitation progress after UKA.

Keywords Gait analysis, Unicompartmental, Postural balance, Postoperative recovery, Knee osteoarthritis

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Introduction

Unicompartmental knee arthroplasty (UKA) represents an effective intervention for medial compartment osteoarthritis (OA), offering distinct advantages over total knee arthroplasty (TKA). By preserving the anterior and posterior cruciate ligaments, UKA enhances postoperative proprioception while minimizing surgical trauma, as evidenced by reduced incision size, lower intraoperative blood loss, accelerated recovery, and superior patient-reported outcomes [1]. Advances in surgical techniques and biomaterials have markedly improved UKA longevity and survival rates, reinforcing its role as an optimal treatment during the "window period" for knee OA management [2, 3]. Driven by an aging global population and the adoption of the "stepped treatment principle" for knee OA [4], the global prevalence of UKA procedures has shown significant growth [5, 6].

Postoperative motor function and balance are critical determinants of patient satisfaction [7]. Traditional assessments of knee arthroplasty outcomes often rely on subjective rating scales incorporating pain perception, self-reported feedback, and auxiliary diagnostic findings. However, these evaluations are susceptible to variability due to psychological factors, environmental conditions, and individual cognitive differences [8]. In contrast, gait analysis provides a precise, quantitative assessment of dynamic and static stability, offering an objective measure of postoperative functional recovery [9]. It has been widely applied in knee replacement research, including comparative studies of TKA and UKA, pre- and post-operative gait assessments in TKA, and analyses of gait patterns in patients with OA relative to healthy individuals. However, investigations into early postoperative gait adaptations following UKA remain limited [10–12]. This study aimed to quantitatively assess gait and stability parameters before and at 1 and 3 months post-UKA, comparing them with healthy controls to enhance understanding of motor function recovery and inform tailored rehabilitation strategies.

Materials and methods

General information

A cohort of 30 patients with unilateral medial compartment knee OA (Kellgren-Lawrence grade ≥ 2) [13] who underwent UKA at the Department of Joint Surgery, Affiliated Hospital of Xuzhou Medical University between May 2021 and 2022 constituted the study group. Additionally, 15 healthy elderly individuals without a history of hip or knee pathology served as controls. All participants provided signed informed consent. Inclusion criteria comprised: (1) a confirmed diagnosis of medial compartment knee OA meeting UKA indications [14]; (2) absence of gait-affecting conditions in other joints of the ipsilateral or contralateral limbs; (3) no postoperative complications, with independent ambulation at 1 and 3 months postoperatively; (4) intact anterior, posterior cruciate, and collateral ligaments verified via clinical assessment; and (5) a minimum follow-up period of 3 months. Exclusion criteria included: (1) comorbidities such as cardiac, pulmonary, or other organ insufficiencies, or neurological disorders; (2) concurrent musculoskeletal conditions impairing ambulation; (3) severe osteoporosis; and (4) incomplete data or loss to follow-up.

Surgical methods

All procedures were performed by a single surgical team under general anesthesia with patients in the supine position. A pneumatic tourniquet was applied at the proximal thigh, and standard aseptic protocols were followed. A medial parapatellar incision was used for joint access, with sequential dissection of the skin and subcutaneous tissues. The joint capsule was incised through a standardized medial parapatellar capsular approach to facilitate the removal of osseous obstructions and excision of the medial meniscus. Osteotomy and prosthesis placement were performed using femoral intramedullary and tibial extramedullary alignment techniques. Following trial mold and shim placement, the flexion-extension gap was evaluated to ensure optimal balance. Upon confirming joint stability, the surgical field was irrigated using a pulse lavage system, and a single-condyle Oxford 3rd generation mobile-bearing prosthesis (Zimmer Biomet, US) was implanted. The wound was closed in layers with sutures, followed by a pressure dressing and tourniquet release. A standardized postoperative rehabilitation protocol was implemented, incorporating nutritional optimization, thromboprophylaxis, and structured physiotherapy. Quadriceps isometric exercises and joint range-of-motion training commenced on postoperative day 1. Assisted ambulation with a walker began within 1–2 days, progressing to unassisted walking approximately two weeks post-surgery.

Gait data collection

Data collection for the UKA group was conducted at Xuzhou Medical University's Biomechanics and Motion Analysis Laboratory at three time points: preoperatively and at 1 and 3 months postoperatively. Gait and stability assessments utilized the British Vicon MX optical motion capture system, which integrates 10 MX infrared cameras, an American ATMI gait 3D dynamometry board (comprising two units), and a Zebris plantar pressure plate from Germany. Data acquisition and analysis were performed using Vicon Nexus and Vicon Polygon software (Oxford Metrics Limited, UK).

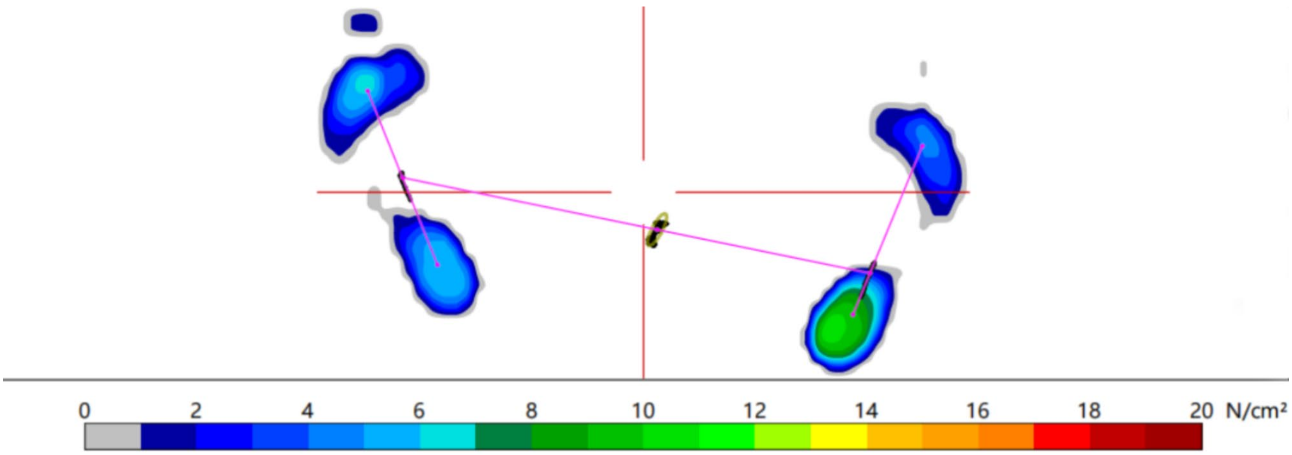

Fig. 1 Center of pressure (COP) trajectories of the double stance

Gait parameter testing

Height, weight, bilateral lower limb lengths, and knee and ankle joint parameters were measured to construct the Plug-in-Gait model. Twenty-eight infrared reflective markers were affixed to anatomical landmarks, including the anterior and posterior iliac spines, thighs, calves, medial and lateral femoral condyles, ankle joints, the posterior aspect of the ankle, and the first and second metatarsals. Participants were instructed to walk at a self-selected adaptive pace, with one familiarization trial preceding three valid trials for data acquisition.

Static stability test

To ensure physiological relaxation, participants rested for five minutes before testing. Positioned within the testing area, they stood with feet shoulder-width apart, arms naturally at their sides, and gaze fixed forward. Each trial lasted 30 s and was repeated three times to obtain mean values. Evaluation parameters included the center of pressure (COP), the 95% confidence ellipse area of the COP trajectory, and the COP path length (Fig. 1).

Scoring scale follow-up

Preoperative and postoperative (1- and 3-month) Hospital for Special Surgery (HSS) knee scores were obtained through outpatient visits or telephone follow-ups [15]. The HSS score provides a comprehensive evaluation of pain perception, functional capacity, and overall health status [16].

Main observational indexes

The analysis encompassed two key aspects: (1) HSS scores recorded preoperatively and postoperatively at 1 and 3 months following UKA and (2) gait parameters, including step speed, stride length, step frequency, gait cycle, and single-support phase ratio, alongside stability metrics such as plantar pressure center, the 95% confidence ellipse area of the COP envelope, and COP path length.

Table 1 Comparison of general information between the UKA and control groups

Subject	UKA group	Control group	*p*
Male/Female	12/18	5/10	0.664
Age	63.80 ± 9.31	61.28 ± 8.60	0.325
BMI	23.01 ± 3.81	24.83 ± 3.04	0.068

UKA, Unicompartmental knee arthroplasty; BMI, Body mass index

Statistical analysis

Statistical analysis was conducted using SPSS 25.0 (IBM, Armonk, NY, USA). Continuous variables were expressed as mean ± standard deviation ($\bar{x} \pm s$), with intra-group comparisons across time points assessed via one-way repeated-measures ANOVA. Inter-group differences were analyzed using independent-sample t-tests. Categorical data were presented as frequencies and compared using the χ^2 test. Statistical significance was defined as $p < 0.05$.

Results

Baseline and demographic criteria

No statistically significant differences were observed between the UKA and control groups in age (63.80 vs. 61.28 years), sex distribution (male/female: 12/18 vs. 5/10), or body mass index (23.01 vs. 24.83) ($p > 0.05$) (Table 1).

Comparison of HSS scores, stability, and gait parameters at different time points within the UKA group

Comparative analysis of HSS scores, COP path length, 95% confidence ellipse area, stride speed, stride length, gait cycle, and single-support time percentage across the three time points—preoperatively and at 1 and 3 months postoperatively—revealed statistically significant differences ($p < 0.05$). Step frequency showed no

Table 2 Comparison of HSS scores and stability parameters at different time points within the UKA group

Subject	Preoperatively	One month postoperatively	Three months postoperatively	*p*
HSS score	68.16 ± 5.65	71.84 ± 5.42	82.44 ± 5.25	< 0.001
COP path length (mm)	96.44 ± 31.00	123.20 ± 54.90	71.84 ± 34.21	< 0.001
95% ellipse area (mm^2)	118.72 ± 34.12	161.48 ± 36.51	68.60 ± 21.34	< 0.001

HSS, Hospital for Special Surgery; UKA, unicompartmental knee arthroplasty; COP, center of pressure

Table 3 Comparison of gait parameters at different time points within the UKA group

Subject	Preoperatively	One month postoperatively	Three months postoperatively	*p*
Pace (m/s)	0.83 ± 0.11	0.92 ± 0.14	1.07 ± 0.19	< 0.001
Stride length (cm)	1.01 ± 0.06	1.04 ± 0.08	1.13 ± 0.05	< 0.001
Step frequency (step/min)	98.40 ± 5.29	101.48 ± 7.90	107.80 ± 8.03	0.001
Step cycle (s)	1.24 ± 0.12	1.17 ± 0.08	1.10 ± 0.06	< 0.001
Single support time (%)	32.90 ± 1.95	34.70 ± 2.61	37.55 ± 2.67	< 0.001

UKA, unicompartmental knee arthroplasty

Table 4 Comparison of gait and balance parameters between the UKA preoperatively and control groups

Subject	Preoperatively	Control group	*P*
COP Path length (mm)	92.20 ± 30.23	36.00 ± 19.40	< 0.001
95% ellipse area (mm^2)	118.72 ± 34.12	30.16 ± 9.25	< 0.001
Pace (m/s)	0.83 ± 0.11	1.19 ± 0.08	< 0.001
Stride length (cm)	1.01 ± 0.06	1.25 ± 0.06	< 0.001
Step frequency (step/min)	98.40 ± 5.29	116.40 ± 6.53	< 0.001
Step cycle (s)	1.24 ± 0.12	1.03 ± 0.06	< 0.001
Single support time (%)	32.90 ± 1.95	40.50 ± 2.20	< 0.001

UKA, unicompartmental knee arthroplasty; COP, center of pressure

Table 5 Comparison of gait and balance parameters between the control group and UKA at three months postoperatively

Subject	Three months postoperatively	Control group	*p*
COP path length (mm)	73.80 ± 36.18	36.00 ± 19.40	< 0.001
95% ellipse area (mm^2)	68.60 ± 21.34	30.16 ± 9.25	< 0.001
Pace (m/s)	1.07 ± 0.19	1.19 ± 0.08	0.008
Stride length (cm)	1.13 ± 0.05	1.25 ± 0.06	< 0.001
Step frequency (step/min)	107.80 ± 8.03	116.40 ± 6.53	< 0.001
Step cycle (s)	1.10 ± 0.06	1.03 ± 0.06	< 0.001
Single support time (%)	37.55 ± 2.67	40.50 ± 2.20	< 0.001

UKA, unicompartmental knee arthroplasty; COP, center of pressure

significant change at 1 month postoperatively relative to baseline ($p > 0.05$) but increased significantly by 3 months ($p < 0.05$) (Tables 2 and 3).

Comparison between the preoperative UKA and control groups

Preoperatively, the UKA group demonstrated significantly lower stride speed, stride length, stride frequency, and single-support time percentage compared to the control group ($p < 0.05$). Conversely, COP path length, 95% confidence ellipse area, and gait cycle duration were significantly higher in the UKA group ($p < 0.05$) (Table 4).

Comparison between the control group and 3 months after UKA

At 3 months post-UKA, the UKA group still exhibited reduced walking speed, stride length, step frequency, and single-support phase percentage compared to the control group, with statistically significant differences ($p < 0.05$). Additionally, COP path length, 95% confidence ellipse area, and gait cycle duration remained significantly elevated relative to controls ($p < 0.05$) (Table 5).

Discussion

While most gait analysis studies on UKA focus on mid- to late-postoperative rehabilitation, early postoperative gait characteristics remain underexplored. For instance, Yue et al. [17] analyzed kinematic and kinetic parameters at 12, 18, and 24 months post-surgery, while Agarwal et al. [18] compared gait rehabilitation outcomes between UKA and TKA after one year. This study integrated gait analysis with a rating scale to compare preoperative and postoperative gait and stability in patients with UKA relative to healthy controls, providing surgeons with an objective assessment of early postoperative biomechanical changes in the lower limbs and facilitating the development of targeted rehabilitation strategies. In this study, HSS scores, step speed, stride length, single-support phase ratio, and gait cycle duration improved significantly postoperatively compared to preoperative levels. However, stability parameters, including COP path length and the 95% confidence ellipse area, worsened at 1 month postoperatively, suggesting an increased risk of falls during early recovery.

HSS scores at 1 and 3 months postoperatively demonstrated significant improvements over baseline, reflecting enhanced joint function and subjective well-being, consistent with previous findings [19–21]. Despite these improvements, orthopedic surgeons primarily rely on objective measures, such as passive joint mobility (range of motion), gait analysis, and imaging studies, to assess postoperative recovery [22, 23]. Gait parameter analysis revealed significant improvements in stride speed, stride length, gait cycle duration, and single-support phase ratio at 1 month postoperatively, with step frequency being the sole exception. Nonetheless, even at 3 months, none of the patients with UKA attained gait characteristics comparable to those of healthy individuals.

Step speed is a critical indicator of functional autonomy. Studenski et al. [24] reported that a step speed exceeding 1.0 m/s correlates with better health outcomes and increased longevity in older adults. Step speed is inherently influenced by stride length and the single-support phase ratio, the latter serving as a key marker of both pain levels and walking ability [25]. Preoperatively, patients with UKA exhibited a lower single-support phase ratio compared to the control group, consistent with prior studies [26, 27]. Notably, the increase in single-support phase ratio at 1 month postoperatively suggests early pain relief, which is reflected in gait improvements. However, this ratio remained lower than that of healthy individuals even at 3 months postoperatively, indicating that residual pain continues to impact functional recovery. This finding underscores the persistent effects of postoperative discomfort on gait mechanics and highlights the need for optimized rehabilitation strategies beyond the initial recovery phase.

Stride length is closely linked to swing phase duration, as an extended swing phase corresponds to increased stride length. Studies suggest that residual knee flexion deformity persists in some patients even one year post-UKA [28], restricting joint mobility and impairing the affected limb's ability to generate forward momentum during the support phase. Additionally, limited knee extension during the swing phase further constrains stride length. At one month postoperatively, stride length showed improvement relative to preoperative levels, indicating partial recovery from flexion deformity. However, by three months, it had yet to reach the levels observed in healthy individuals. Step frequency, a key indicator of functional recovery following UKA, correlates positively with walking speed. Although step frequency exhibited a modest increase at one month postoperatively, the change was not statistically significant, aligning with previous studies [29, 30]. This lack of significant improvement may stem from persistent gait abnormalities caused by chronic knee OA, which persist postoperatively due to factors such as residual pain, quadriceps muscle impairment, and psychological barriers [31].

Diminished postural stability markedly increases fall risk, a leading cause of disability and mortality among the elderly [32]. COP path length and the 95% confidence ellipse area of the pressure center serve as critical metrics for assessing standing balance. While prior studies report substantial stability improvements by four months post-UKA [33], data on early postoperative stability remain scarce. This study demonstrated that stability declined at one month postoperatively compared to baseline but improved by three months. Nevertheless, none of the patients achieved balance metrics comparable to those of healthy individuals. Proprioception, muscle strength, and plantar sensory input are integral to postural stability and fall prevention [34, 35]. The cruciate ligaments, particularly rich in proprioceptors, play a crucial role in these functions [36, 37]. Although UKA preserves the cruciate ligaments, obesity and excessive knee musculature activation in patients with OA often contribute to ligament degeneration and progressive laxity, potentially impairing proprioception. This may partially explain the persistent stability deficits observed beyond three months postoperatively. To address proprioceptive impairments, elderly patients are encouraged to engage in exercises such as Tai Chi and sports-based training [38, 39]. Poor stability during the first postoperative month is primarily attributed to psychological factors and reduced muscle strength. Fear of falling often leads patients to limit movement in the operated limb, resulting in asymmetrical weight distribution and impaired balance during activities [40]. Reduced weight-bearing and muscle activity further diminish quadriceps stress, delaying strength recovery and exacerbating instability [41]. Integrating unilateral limb exercises into rehabilitation protocols may facilitate quadriceps recovery, enhance postural stability, and mitigate fall risk.

Early postoperative gait characteristics following UKA highlight the necessity of a structured, phased rehabilitation program. The initial phase (0–4 weeks post-surgery) focuses on pain and edema management, restoration of basic knee range of motion, and initiation of mild passive and active movements. Partial weight-bearing training is cautiously introduced, with an emphasis on fall prevention. Between weeks 4 and 12, rehabilitation shifts toward strengthening periarticular musculature, optimizing gait mechanics, and restoring functional mobility. Gradual progression in weight-bearing exercises is prioritized to prevent compensatory overuse of the contralateral limb. Beyond 12 weeks, rehabilitation aims to normalize gait patterns and enhance joint stability through continued strengthening, flexibility training, and gait correction. Functional tasks such as stair navigation and prolonged ambulation are reintroduced incrementally. Rehabilitation should be tailored to the patient's recovery trajectory and gait analysis outcomes, ensuring a progressive and individualized approach to functional restoration. Periodic evaluations and program modifications are critical to facilitating a seamless transition back to daily activities while optimizing joint stability and mobility postoperatively.

This study has several limitations. Gait analysis was restricted to a 3-month postoperative period, and joint kinematics were not assessed. Additionally, within the UKA cohort, no comparison was made between mobile-bearing and fixed-bearing prostheses, despite the potential influence of prosthesis type, design principles, and biomechanical constraints on postoperative gait performance [42]. Furthermore, the relatively small sample size limits generalizability, underscoring the need for multicenter studies with larger cohorts and extended follow-up durations.

Conclusions

Stability remained compromised at one month postoperatively. By three months, gait performance and postural stability had significantly improved relative to baseline but remained inferior to those of healthy individuals. Addressing patients' apprehension toward movement while implementing fall prevention strategies is essential for optimizing recovery. Targeted joint mobility exercises and rehabilitation protocols focused on proprioceptive training and muscle strengthening should be emphasized. Gait analysis offers a quantitative framework for assessing postoperative recovery, enabling clinicians to evaluate surgical outcomes with greater objectivity and refine rehabilitation strategies accordingly.

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Author contributions
X.G., C.Z., and H.L. conceptualized the study design. Manuscript preparation was undertaken by X.G. and X.Z. Data collection and analysis were carried out by X.G., C.Z., and J.C. Experimental guidance was provided by H.L., who also conducted a critical revision of the manuscript. All authors reviewed and approved the final version.

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Data availability
No datasets were generated or analysed during the current study.

Declarations

Ethics approval and consent to participate
The study received approval from the Ethics Committee of the Affiliated Hospital of Xuzhou Medical University. Written informed consent was obtained from all participants prior to their inclusion. All procedures adhered to applicable guidelines and regulations, including the *Declaration of Helsinki*.

Consent for publication
Participants provided written consent permitting the publication of their clinical or personal details, including any identifying images associated with the study.

Competing interests
The authors declare no competing interests.

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References

1. Wilson HA, Middleton R, Abram SGF, Smith S, Alvand A, Jackson WF, Bottomley N, Hopewell S, Price AJ. Patient relevant outcomes of unicompartmental versus total knee replacement: systematic review and meta-analysis. BMJ. 2019;364:l352.
2. Kim KT, Lee S, Lee JI, Kim JW. Analysis and treatment of complications after unicompartmental knee arthroplasty. Knee Surg Relat Res. 2016;28(1):46–54.
3. El-Galaly A, Kappel A, Nielsen PT, Jensen SL. Revision risk for total knee arthroplasty converted from medial unicompartmental knee arthroplasty: comparison with primary and revision arthroplasties, based on Mid-Term results from the Danish knee arthroplasty registry. J Bone Joint Surg Am. 2019;101(22):1999–2006.
4. Bannuru RR, Osani MC, Vaysbrot EE, Arden NK, Bennell K, Bierma-Zeinstra SMA, Kraus VB, Lohmander LS, Abbott JH, Bhandari M, et al. OARSI guidelines for the non-surgical management of knee, hip, and polyarticular osteoarthritis. Osteoarthritis Cartilage. 2019;27(11):1578–89.
5. Halawi MJ, Barsoum WK. Unicondylar knee arthroplasty: key concepts. J Clin Orthop Trauma. 2017;8(1):11–3.
6. Kahlenberg CA, Richardson SS, Gruskay JA, Cross MB. Trends in utilization of total and unicompartmental knee arthroplasty in the united States. J Knee Surg. 2021;34(10):1138–41.
7. Ighani Arani P, Wretenberg P, Ottosson J, W-Dahl A. Pain, function, and satisfaction after total knee arthroplasty, with or without bariatric surgery. Obes Surg. 2022;32(4):1164–9.
8. Bach CM, Nogler M, Steingruber IE, Ogon M, Wimmer C, Gobel G, Krismer M. Scoring systems in total knee arthroplasty. Clin Orthop Relat Res 2002;(399):184–96.
9. Baker R, Esquenazi A, Benedetti MG, Desloovere K. Gait analysis: clinical facts. Eur J Phys Rehabil Med. 2016;52(4):560–74.
10. Çankaya D, Aktı S, Ünal ŞB, Sezgin EA. Unicompartmental knee arthroplasty results in a better gait pattern than total knee arthroplasty: gait analysis with a smartphone application. Jt Dis Relat Surg. 2021;32(1):22–7.
11. Bączkowicz D, Skiba G, Czerner M, Majorczyk E. Gait and functional status analysis before and after total knee arthroplasty. Knee. 2018;25(5):888–96.
12. Boekesteijn RJ, Keijsers NLW, Defoort K, Mancini M, Bruning FJ, El-Gohary M, Geurts ACH, Smulders K. Real-world gait and turning in individuals scheduled for total knee arthroplasty. Clin Biomech (Bristol Avon). 2024;119:106332.
13. Kellgren JH, Lawrence JS. Radiological assessment of osteo-arthrosis. Ann Rheum Dis. 1957;16:494–502.
14. Kozinn SC, Scott R. Unicondylar knee arthroplasty. J Bone Joint Surg Am. 1989;71(1):145–50.
15. Insall JN, Ranawat CS, Aglietti P, Shine J. A comparison of four models of total knee-replacement prostheses[J]. J Bone Joint Surg Am. 1976;58(6):754–65.
16. Kuo AC, Giori NJ, Bowe TR, Manfredi L, Lalani NF, Nordin DA, Harris AHS. Comparing methods to determine the minimal clinically important differences in Patient-Reported outcome measures for veterans undergoing elective total hip or knee arthroplasty in veterans health administration hospitals. JAMA Surg. 2020;155(5):404–11.
17. Li Y, Mario L, Zhao X, Zhu Z, Tian R, Li Z, Kong N. Evaluation of knee kinematics and moments during active deep flexion activity after Oxford Mobile-Bearing medial UKA-A Two-Year Follow-Up study. J Knee Surg. 2022;35:896–903.
18. Agarwal A, Miller S, Hadden W, Johnston L, Wang W, Arnold G, Abboud RJ. Comparison of gait kinematics in total and unicondylar knee replacement surgery. Ann R Coll Surg Engl. 2019;101:391–8.
19. Zhang D, Zhang X: Safety and Efficacy of Unicondylar Knee Prosthesis Treatment for Unicompartmental Osteoarthritis of the Knee Joint. 2022,

2022:2938380. Wang L, Wang Q, Li Q, Song F: A Comparative Study of Total Knee Arthroplasty and Unicondylar Knee Arthroplasty in the Treatment of Knee Osteoarthritis. Contrast Media Mol Imaging 2022;2022:7795801.
20. Xue H, Ma T, Wen T, Yang T, Xue L, Lei X, Ji J, Zhang W, Tu Y. Short- and mid-term effectiveness of unicompartmental knee arthroplasty for post-traumatic arthritis of knee. Zhongguo Xiu Fu Chong Jian Wai Ke Za Zhi. 2023;37(6):647–52.
21. Choy WS, Kim KJ, Lee SK, Yang DS, Lee NK. Mid-term results of Oxford medial unicompartmental knee arthroplasty. Clin Orthop Surg. 2011;3(3):178–83.
22. Parratte S, Sah A, Batailler C. Safe and reliable clinical outcomes at 2 years of a fixed-bearing partial knee arthroplasty with a morphometric tibial tray in a large worldwide population. Knee Surg Sports Traumatol Arthrosc. 2023;31(3):814–21.
23. Adamska O, Modzelewski K, Szymczak J, Swiderek J, Maciag B, Czuchaj P, Poniatowska M, Wnuk A. Robotic-Assisted total knee arthroplasty utilizing NAVIO, CORI imageless systems and manual TKA accurately restore femoral rotational alignment and yield satisfactory clinical outcomes: A randomized controlled trial. Med (Kaunas) 2023;59(2).
24. Studenski S, Perera S, Patel K, Rosano C, Faulkner K, Inzitari M, Brach J, Chandler J, Cawthon P, Connor EB, et al. Gait speed and survival in older adults. JAMA. 2011;305(1):50–8.
25. McKean KA, Landry SC, Hubley-Kozey CL, Dunbar MJ, Stanish WD, Deluzio KJ. Gender differences exist in Osteoarthritic gait. Clin Biomech (Bristol Avon). 2007;22(4):400–9.
26. Casartelli NC, Item-Glatthorn JF, Bizzini M, Leunig M, Maffiuletti NA. Differences in gait characteristics between total hip, knee, and ankle arthroplasty patients: a six-month postoperative comparison. BMC Musculoskelet Disord. 2013;14:176.
27. Gianzina E, Kalinterakis G, Delis S, Vlastos I, Platon Sachinis N, Yiannakopoulos CK. Evaluation of gait recovery after total knee arthroplasty using wearable inertial sensors: A systematic review. Knee. 2023;41:190–203.
28. Nha KW, Shon OJ, Kong BS, Shin YS. Gait comparison of unicompartmental knee arthroplasty and total knee arthroplasty during level walking. PLoS ONE. 2018;13(8):e0203310.
29. Hao P, Yang L, He R, Chen H, Sun M, Liang S. [Analysis of gait and effectiveness after unicompartmental knee arthroplasty]. Zhongguo Xiu Fu Chong Jian Wai Ke Za Zhi. 2020;34(11):1369–75.
30. Dong M, Fan H, Yang D, Sun X, Yan C, Feng Y. Comparison of Spatiotemporal, kinematic, and kinetic gait characteristics in total and unicompartmental knee arthroplasty during level walking: A systematic review and meta-analysis. Gait Posture. 2023;104:58–69.
31. Kim MK, Yoon JR, Yang SH, Shin YS. Unicompartmental knee arthroplasty fails to completely restore normal gait patterns during level walking. Knee Surg Sports Traumatol Arthrosc. 2018;26(11):3280–9.
32. Mat S, Ng CT, Tan PJ, Ramli N, Fadzli F, Rozalli FI, Mazlan M, Hill KD, Tan MP. Effect of modified Otago exercises on postural balance, fear of falling, and fall risk in older fallers with knee osteoarthritis and impaired gait and balance: A secondary analysis. PM R. 2018;10(3):254–62.
33. Baumann F, Bahadin O, Krutsch W, Zellner J, Nerlich M, Angele P, Tibesku CO. Proprioception after bicruciate-retaining total knee arthroplasty is comparable to unicompartmental knee arthroplasty. Knee Surg Sports Traumatol Arthrosc. 2017;25(6):1697–704.
34. Zhang W, Low LF, Schwenk M, Mills N, Gwynn JD, Clemson L. Review of gait, cognition, and fall risks with implications for fall prevention in older adults with dementia. Dement Geriatr Cogn Disord. 2019;48(1–2):17–29.
35. Henry M, Baudry S. Age-related changes in leg proprioception: implications for postural control. J Neurophysiol. 2019;122(2):525–38.
36. Koc BB, Jansen EJP, van Dijk P, Emans PJ, Lataster A. Mechanoreceptors observed in a ligamentous structure between the posterior Horn of the lateral meniscus and the anterior cruciate ligament. Knee Surg Sports Traumatol Arthrosc. 2021;29(6):1701–8.
37. Chun KC, Shin CH, Kang HT, Kwon HY, Jo HJ, Chun CH. Mechanoreceptors in remnant posterior cruciate ligament and Achilles tendon allografts after remnant-Preserving posterior cruciate ligament reconstruction: Hematoxylin-Eosin and immunohistochemical assessments. Am J Sports Med. 2020;48(12):3013–20.
38. Zhang C, Sun W, Yu B, Song Q, Mao D. Effects of exercise on ankle proprioception in adult women during 16 weeks of training and eight weeks of detraining. Res Sports Med. 2015;23(1):102–13.
39. Sadeghi H, Hakim MN, Hamid TA, Amri SB, Razeghi M, Farazdaghi M, Shakoor E. The effect of exergaming on knee proprioception in older men: A randomized controlled trial. Arch Gerontol Geriatr. 2017;69:144–50.
40. Soleimani R, Jalali MM, Mirbolook AR. Predictors of fear of falling among Iranian older adults with hip fracture and controls. Clin Gerontol. 2020;43(4):391–9.
41. Mueller MJ, Maluf KS. Tissue adaptation to physical stress: a proposed physical stress theory to guide physical therapist practice, education, and research. Phys Ther. 2002;82(4):383–403.
42. Kaneko T, Kono N, Mochizuki Y, Hada M, Toyoda S, Ikegami H, Musha Y. Midterm comparison of tibial fixation between posterior Cruciate-Retaining and substituting porous tantalum total knee arthroplasty: Three-Dimensional computed tomography analysis. J Knee Surg. 2021;34(1):47–56.

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