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REVIEW

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A systematic comparative analysis of gait characteristics in patients undergoing total knee arthroplasty and unicompartmental knee arthroplasty: a review study

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Abstract

Background This study systematically reviews recent research comparing clinical outcomes and gait function changes in patients undergoing total knee arthroplasty (TKA) versus unicompartmental knee arthroplasty (UKA).

Methods A systematic search of the Web of Science, PubMed, and Embase databases was conducted, covering publications from January 2013 to September 2024, to identify studies evaluating changes in clinical scores and gait parameters in patients undergoing TKA or UKA. Following stringent selection criteria, data were synthesized from studies involving 171 TKA and 148 UKA patients, focusing on reported gait outcomes and aggregating findings for comprehensive analysis. Direct comparisons between TKA and UKA were performed to assess differences in clinical scores and gait parameters, aiming to elucidate the relative efficacy of each surgical approach and provide robust evidence for clinical decision-making.

Results Ten studies met the inclusion criteria for post-operative gait outcome comparisons between TKA and UKA, with seven studies also addressing clinical scores. One study reported greater improvement in WOMAC scores for the UKA group at 6 months post-operation ($P<0.05$), while another found superior EQ-5D scores for UKA patients at 1 year post-surgery ($P<0.05$). Conversely, five studies found no significant differences in clinical scores between groups at 1 year ($P>0.05$). All ten studies assessed gait parameter recovery, with three studies showing no significant differences at 1 year ($P>0.05$). However, seven studies identified superior gait recovery in the UKA group across various parameters, including walking speed, step and stride length, single support time, heel strike force, knee joint range of motion, knee flexion angles during different gait phases, peak knee adduction moment, peak tibial internal rotation moment, gait symmetry, and stride length symmetry ($P<0.05$).

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Conclusions The analysis indicates that UKA offers certain advantages in post-operative gait improvements compared to TKA, though these do not translate into significant differences in conventional clinical scoring systems. To enhance the reliability and generalizability of these findings, future studies should involve larger-scale, prospective randomized controlled trials.

Keywords Gait analysis, Total knee arthroplasty, Unicompartmental knee arthroplasty

Introduction

Osteoarthritis (OA) is a leading cause of disability among the elderly [1], predominantly affecting weight-bearing joints such as the hip, knee, and ankle, with the knee being the most commonly impacted site [2, 3]. Knee osteoarthritis (KOA) is a degenerative condition marked by joint pain, quadriceps weakness, and altered movement patterns, with a multifactorial pathogenesis involving gender, age, body mass index (BMI), lower limb alignment, and biomechanical factors [4–7]. For patients with KOA eligible for both Total Knee Arthroplasty (TKA) and Unicompartmental Knee Arthroplasty (UKA), selecting the most suitable surgical approach poses a significant challenge, often depending on the surgeon's expertise and clinical judgment. Although both TKA and UKA are viable options due to overlapping indications [8], their recovery outcomes and efficacy may vary considerably.

In both academic research and clinical settings, UKA has shown several advantages over TKA. A key benefit of UKA is the preservation of the cruciate ligaments, which are essential for proprioception and stability of the knee joint [9]. This preservation not only facilitates simpler future revision surgeries but also broadens the applicable age range, making UKA a more flexible option. However, the high prosthesis survival rate associated with TKA remains a significant advantage [10]. Additionally, factors such as surgeons' preferences, varying surgical expertise, and diverse patient selection criteria play a substantial role in clinical decision-making, reflecting the complexity and individualization inherent in medical practice [11]. For patients in this overlapping category, a comprehensive evaluation of the patient's specific condition is essential to determine the most suitable treatment plan.

Previous comparative studies of UKA and TKA in KOA management have primarily focused on metrics such as prosthesis survival rates, surgical duration, intraoperative blood loss, knee function scores, and range of motion (ROM) [12–15]. While gait analysis offers an objective and comprehensive assessment of post-operative knee function recovery, limited research has investigated post-operative gait outcomes in depth between UKA and TKA. To address this gap, the present study systematically reviews and analyzes gait parameter data from existing literature on the post-operative outcomes of these surgical approaches. This analysis aims to elucidate the differences in treatment efficacy between UKA and TKA, providing a more nuanced understanding of how each procedure affects gait recovery. The findings offer a scientific basis for optimizing surgical strategies and improving clinical outcomes for patients with KOA.

Methods

Search strategy

This study conducted a systematic and comprehensive search of authoritative databases, including Web of Science, PubMed, and Embase, covering publications from January 2013 to September 2024, with a focus on English-language studies. Key search terms such as "gait," "gait analysis," "unicompartmental knee arthroplasty," "unicompartmental knee replacement," "total knee arthroplasty," "total knee replacement," and "knee osteoarthritis" were employed to ensure a thorough and accurate search. This strategy aimed to identify the latest research on gait analysis in patients who underwent TKA or UKA. Retrieved studies were then rigorously screened based on predefined inclusion and exclusion criteria to ensure scientific rigor and relevance to the study's core theme, facilitating a detailed comparison of the effects of TKA and UKA on post-operative gait and related influencing factors.

Inclusion and exclusion criteria

Inclusion and exclusion criteria in the present study were based on the Population, Intervention, Comparator, Outcomes, and Study designs.

1. 1.Population: patients with knee osteoarthritis.
2. Intervention: after TKA and UKA.
3. Comparator: UKA and TKA.
4. Outcome: clinical scores: Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC), Knee Society Score (KSS), Oxford Knee Score (OKS), Visual Analog Scale (VAS), EuroQol Group 5-Dimension Self-Report Questionnaire (EuroQoL).gait parameters: walking speed, cadence, step length, step time, stride length, gait cycle duration, single-leg stance, stance phase duration, swing phase duration, knee flexion angle at initial contact, maximum knee flexion during loading response, minimum knee flexion at terminal stance, maximum knee flexion during the swing phase, varus angle, internal rotation angle, vertical ground reaction force, knee adduction moment, knee

extensor moment, knee internal rotation moment, peak knee flexion moment, peak tibial internal rotation moment during walking, and knee joint ROM.
5. Study design: retrospective studies, prospective studies.

The exclusion criteria were as follows: (1) reviews, case reports, and conference abstracts; (2) studies with incomplete or missing data; (3) original studies with unclear experimental design; and (4) studies not aligned with the inclusion criteria regarding study objectives and interventions.

Study selection

Two researchers independently selected relevant studies for detailed evaluation based on titles and abstracts. When abstracts lacked sufficient detail, the full texts were reviewed. Discrepancies between the researchers' evaluations were resolved through discussion with a third researcher until consensus was reached. Data extraction focused on key study characteristics, such as the first author's name, publication year, study design, journal, participants' average age, follow-up duration, BMI, gait analysis system used, sample size for UKA and TKA groups, testing tasks, and primary outcomes. Following a stringent initial screening, data from the selected studies were systematically extracted and compiled (Table 1).

Outcome measures

Clinical outcomes of TKA and UKA patients were compared by synthesizing data from various studies, utilizing metrics such as the WOMAC, KSS, OKS, VAS, and EuroQoL to comprehensively evaluate functional recovery and quality of life (Table 2).

A detailed analysis of gait parameters was conducted to better understand the differential impact of these surgical procedures on gait characteristics. The parameters assessed included spatiotemporal factors (walking speed, cadence, step length, step time, stride length, gait cycle duration, single-leg stance, stance phase duration, swing phase duration), kinematic factors (knee flexion angle at initial contact, maximum knee flexion during loading response, minimum knee flexion at terminal stance, maximum knee flexion during the swing phase, varus angle, internal rotation angle), and kinetic factors (vertical ground reaction force, knee adduction moment, knee extensor moment, knee internal rotation moment, peak knee flexion moment, peak tibial internal rotation moment during walking, and knee joint ROM) (Table 3).

Results

Search and selection

The database search initially yielded 789 relevant articles. After the removal of 122 duplicates, 667 studies remained for further evaluation. A review of the abstracts led to the exclusion of 511 studies that did not align with the study's objectives. The full texts of the remaining 156 articles were then assessed, resulting in the inclusion of 10 studies that met the specified inclusion criteria (Fig. 1).

Basic characteristics of the included literature

The analysis included 10 studies [16–25] with a total of 319 participants, comprising 171 in the TKA group and 148 in the UKA group, aged 59.40 to 77.40 years. Among the selected studies, 8 were retrospective and 2 were prospective. Follow-up duration exceeded 1 year in 9 studies, while one study had a 6-month follow-up period. Clinical scores for UKA and TKA patients were compared in 7 studies (Table 2), while all 10 studies evaluated gait outcomes between the two groups (Table 3). Motor task assessment varied: 7 studies focused on level walking, 1 included both level and inclined walking, another employed a treadmill with force plates for gait analysis, and 1 involved downhill walking (Table 1).

Clinical outcome scores

Most studies employed multiple clinical outcome measures before and after surgery, including WOMAC, KSS, OKS, EuroQol 5-Dimension Questionnaire (EQ-5D), and VAS, among others (Table 2).

Clinical scores for UKA and TKA patients were compared in 7 of the 10 studies [16, 18, 20, 22–25]. One study reported that at 6 months postoperatively, the UKA group showed greater improvement in WOMAC scores for knee pain, function, and overall score compared to the TKA group ($P<0.05$). Another study found that at 1 year postoperatively, the UKA group achieved a higher EQ-5D score than the TKA group ($P<0.05$). The remaining five studies observed no significant differences in clinical scores between the two groups at the 1-year mark ($P>0.05$) (Table 2).

Gait variables

Ten studies compared gait parameters between UKA and TKA patients [16–25] (Table 3). Three studies found no significant differences in gait parameters between the two groups at one year post-operation ($P>0.05$). In contrast, seven studies reported notable differences in gait recovery. Wiik [20] indicated that at one year post-operation, the UKA group showed superior walking speed, step length, heel strike force, and stride length compared to the TKA group ($P<0.05$), but exhibited lower ground reaction force and impulse during the stance phase ($P<0.05$). The other six studies further

Table 1 Details of the included studies

Authors	Year	Study type	Journal	Mean age (years)		Follow-up (months)	Sample size (M/F)		Implant type		Body mass index (kg/m²)		Inertial system	Tasks	Main outcome parameters
				UKA	TKA		UKA	TKA	UKA	TKA	UKA	TKA			
Vilhelm Wiik et al. [16]	2019	RCS	Royal College of Surgery	65.50	65.77	12	8/6	9/4	NA	NA	26.43	30.38	VICON system	Level walking	C, WS, F2, F6,R, F5
Nishizawa et al. [17]	2020	PCS	Asia Pac J Sports Med Arthrosc Rehabil Technol	72.20	77.40	Mean 12	2/11	0/15	9Fixed	PS	25.20	27.10	NA	Level walking	WS, ROM, F1, F3,KAM, KIRM,
De Vroey et al. [18]	2019	RCS	Gait posture	66.50	64.50	At least 12	4/2	2/6	NA	PS	30.08	32.99	Six cameras system	Level walking	WS, C, S L, ROM, F1, F2, F3, F4,
Friesenbichler et al. [19]	2018	PCS	The Knee	61.00	63.00	Mean 6	9/9	9/9	Fixed	PS	27.00	27.10	CIR Systems Inc	Level walking	WS, SL, S,MVC,
Wiik et al. [20]	2013	RCS	The Journal of Arthroplasty	65.90	67.80	At least 12	10/13	9/24	NA	NA	30.00	29.40	Instrumented treadmill	Level walking	WS, C,SL, OKS, vert-GRF
Igor Komnik et al. [21]	2016	RCS	PLOS ONE	60.50	60.00	At least 12	7/6	7/4	Fixed	4CR, 7PS	27.70	27.50	VICON system	Level and Sloped Grounds	WS, SL, KAM, KIRM,
Jones et al. [22]	2016	RCS	Bone Joint Journal	65.00	68.00	At least 12	12(NA)	12(NA)	Mobile	CR	29	30	Kistler Gaitway	Twalk readmill instrumented with force plates	WS, OKS, vert-GRF
Anatole V et al. [23]	2014	RCS	Knee	64.8 6	67.5	At least 12	9/10	6/8	NA	CR	29.3	29.1	Instrumented treadmill	Downhill walking	WS, OKS, vert-GRF, WS, C, SL, Stride L, Contact T, ST, S, SW,
Miller et al. [24]	2018	RCS	Royal College of Surgery	65.77	65.15	At least 12	13(NA)	13(NA)	NA	CR	26.68	30.38	VICON system	Level walking	C, WS, Stride L, Stride T, SL,
Çankaya et al. [25]	2021	RCS	Joint Diseases and Related Surgery	59.40	61.70	At least 12	1/16	2/32	Fixed	CR	27.90	29.10	Smartphone application	Level walking	WS, C,SL, KSS

Abbreviations: RCS, retrospective comparative study; PCS, prospective comparative study; M, male; F, female; NA, not available; CR, cruciate retaining; PS, posterior stabilized; F1, knee flexion at heel strike; F2, maximum knee flexion at loading; F3, minimum knee flexion at terminal stance; F4, maximum knee flexion at swing; F5, total knee flexion at gait cycle; F6, Flexion at loading response; WS, walking speed; C, cadence (step/min); SL, step length (m); Stride L, stride length (m); SW, step widt; ST, Step time; Stride T, Stride Time; Contact T, Contact time; S, single-limb support phase; MVC, Quadriceps MVC torque; ROM, Range of movement in the gait cycle; KSS, Knee Society Score; OKS, Oxford Knee Score; vert-GRF, vertical ground reaction force; KAM, knee adduction moment; KIRM, knee internal rotation moment

Table 2 Comparison of clinical outcome scores between UKA and TKA patients

Authors	Outcome parameters	Preoperatively			6 months postoperatively			1 year postoperatively		
		UKA mean (SD)	TKA mean (SD)	*P*-value	UKA mean (SD)	TKA mean (SD)	*P*-value	UKA mean (SD)	TKA mean (SD)	*P*-value
Vilhelm Wiik et al. [16]	KSS-function	65.00	55.77	0.28				92.14	92.31	0.97
	KSS-total	42.36	37.85	0.61				91.29	88.62	0.29
De Vroey et al. [18]	OKS-score							44.00	41.50	NS
Friesenbichler et al. [19]	WOMAC-pain				100	90	0.014			
	WOMAC-function				97.1	88.2	0.005			
	WOMAC-stiffness				93.8	75	0.017			
Jones et al. [22]	OKS							44	43	NS
Anatole et al. [23]	Oxford							44.8 (2.9)	41.9 (4.7)	0.03
	UCLA							7.6 (1.3)	7.0 (1.4)	NS
	EQ-5D							0.93 (0.10)	0.82 (0.13)	0.02
	EQ-VAS							84.9 (14.1)	77.1 (15.4)	NS
Miller et al. [24]	Knee score	37.08	42.15	NS				88.50	91.08	NS
	Knee function score	55.00	64.62	NS				92.50	94.62	NS
Cankaya et al. [25]	KSS-knee	56.5 ± 11.5	54.6 ± 12.7	NS				90.8 (4.0)	89.4 (4.7)	NS
	KSS-function	55.6 ± 12.7	53.9 ± 13.9	NS				87.1 (8.6)	82.8 (7.4)	NS

Abbreviations: KSS, Knee Society Score; WOMAC, Western Ontario and McMaster Universities Arthritis Index; OKS, Oxford Knee Score; EQ-VAS, EuroQol 5 part questionnaire; VAS, Visual Analog Scale; EQ-5D, EuroQol 5 part questionnaire; NS, Not Significant;

highlighted UKA's advantages in post-operative gait parameters. Nishizawa [17] found that at one year post-operation, the UKA group demonstrated a greater ROM and maximum knee flexion during the stance phase than the TKA group ($P<0.05$) while having a lower minimum knee flexion angle during stance ($P<0.05$). Friesenbichler [19] reported that six months post-operation, UKA patients had a longer single-leg stance time compared to TKA patients ($P<0.05$). Jones [22] showed that at one year post-operation, the UKA group achieved a higher maximum walking speed than the TKA group ($P<0.05$). Anatole V [23] found that at one year post-operation, the UKA group had greater walking speed, step length, and stride length compared to TKA patients ($P<0.05$). Nishizawa [17] also noted that one year post-operation, the UKA group outperformed in active knee joint ROM, walking speed, knee flexion angle at heel contact, mid-stance knee flexion angle, peak knee adduction moment, and peak tibial internal rotation moment during walking ($P<0.05$). Lastly, Cankaya [25] observed that at one year post-operation, UKA patients demonstrated better walking speed, gait time symmetry, and step length symmetry than TKA patients ($P<0.05$).

Discussion

When comparing the gait characteristics of UKA and TKA patients, we reviewed previous studies and found that there was currently limited literature analysing and comparing the gait of these two patient groups. This study adopts a more systematic and comprehensive approach to summarising gait characteristics, increasing the sample size of gait parameter analysis to ensure data representativeness and breadth. To our knowledge, this review is one of the most comprehensive articles to date that compares and analyses gait in UKA and TKA patients from multiple dimensions, including clinical scores and gait parameters.

Postoperative walking speed is a key indicator of a patient's overall health and functional recovery status [26, 27]. In five studies reviewed (Table 3), UKA patients consistently demonstrated superior walking speed within the first year post-surgery compared to TKA patients [17, 19, 22, 23, 25]. This advantage is likely attributable to the less invasive nature of UKA, which targets only a single knee compartment, thereby preserving more bone mass and ligament structures [28]. The minimally invasive approach results in fewer alterations to the patient's movement patterns, enabling the retention of preoperative walking habits. Consequently, muscle memory is better maintained, and familiar movement patterns are preserved. Additionally, the reduced invasiveness of UKA is associated with lower postoperative pain, potentially accelerating the overall recovery process and allowing earlier initiation of gait rehabilitation and resumption of daily activities, which likely contributes to the observed superior walking speed in UKA patients.

Stride length and step length are critical parameters for evaluating postoperative functional recovery [29–31]. Research indicates that both TKA and UKA patients experience pain relief, improved joint alignment, and

Table 3 Comparison of gait parameters between UKA and TKA patients

Authors	Outcome parameters	Preoperatively			6 months postoperatively			1 year postoperatively		
		UKA mean (SD)	TKA mean (SD)	*P*-value	UKA mean (SD)	TKA mean (SD)	*P*-value	UKA mean (SD)	TKA mean (SD)	*P*-value
Vilhelm Wiik et al. [24]	Cadence (steps/min)							105.19	102.19	0.27
	Speed (m/s)							1.05	1.01	0.31
	Stride length (m)							1.20	1.18	0.72
	Maximum angle in stance phase (°)							7.11	8.55	0.27
	Minimum angle in stance phase (°)							3.96	7.17	< 0.001
	Range of movement in the gait cycle (°)							46.68	41.49	< 0.001
	Maximum flexion in the gait cycle (°)							51.01	47.97	0.98
	Maximum flexion in stance phase (°)							48.43	43.87	0.01
	Flexion at foot strike (°)							2.84	0.92	0.08
Nishizawa et al. [17]	Gait speed (m/s)							1.06 (0.18)	0.85 (0.20)	0.011
	ROM (Flexion) (°)	136.4 ± 6.7	114.3 ± 10.3	< 0.001				134.2 (5.5)	116.7 (12.2)	< 0.001
	FTA (°)	176.7 ± 3.6	186.8 ± 5.6	< 0.001				175.2 (3.0)	175.0 (2.0)	0.80
	Knee flexion angle at heel contact(°)							3.8 (4.8)	10.6 (4.6)	< 0.01
	Knee flexion angle during mid-stance phase (°)							1.3 (6.4)	8.2 (5.1)	0.018
	Peak knee adduction angle during stance phase (°)							1.5 (4.8)	0.5 (3.0)	0.70
	Peak knee internal rotation angle in walking (°)							7.8 (5.5)	7.2 (4.9)	0.63
	Peak knee flexion moment in walking (Nm/kg)							0.34 (0.21)	0.35 (0.20)	0.77
	Peak knee adduction moment in walking (Nm/kg)							0.56 (0.15)	0.44 (0.15)	0.029
	Peak tibial internal rotation moment in walking(Nm/kg)							0.15 (0.06)	0.06 (0.04)	< 0.001

Table 3 (continued)

Authors	Outcome parameters	Preoperatively			6 months postoperatively			1 year postoperatively		
		UKA mean (SD)	TKA mean (SD)	*P*-value	UKA mean (SD)	TKA mean (SD)	*P*-value	UKA mean (SD)	TKA mean (SD)	*P*-value
De Vroey et al. [18]	Cycle time (s)							1.24(0.15)	1.30(0.11)	NS
	Stance time (s)							0.73(0.08)	0.73(0.07)	NS
	Swing time (s)							0.51 (0.90)	0.51 (0.04)	NS
	Cadence (steps/minute)							99.25 (12.59)	93.96 (9.47	NS
	Speed (m/s)							0.90(0.18)	0.75(0.10	NS
	Stride width (cm)							14.9 (3.53)	14.0 (2.30)	NS
	Stride length (cm)							1.09 (17.31)	0.98 (12.90)	NS
	KNEE peak extension/plantarflexion at loading response (°)							6.08	2.88	NS
	Knee peak flexion/dorsiflexion at loading response (°)							10.98	6.86	NS
	Knee peak extension/plantarflexion at midstance (°)							8.18	5.09	NS
	Knee peak flex/dorsiflexiom at midstance (°)							10.94	6.76	NS
	Knee peak extension/plantarflexion at terminal stance (°)							7.63	5.31	NS
	Knee peak flex/dorsiflexionation terminal stance (°)							15.63	11.68	NS
	Knee time peak extension/plantarflexion angle (%)							6.83	4.75	NS
	Knee time peak flexion/dorsiflexion angle (%)							59.00	59.00	NS
Friesenbichler et al. [19]	Gait Speed (cm/s)				141.0	141.8	NS			
	Step length (cm)				73.9	75.1	NS			
	Single-limb support (%)				40.0	38.6	0.006			
	Quadriceps MVC torque (Nm/kg)				1.9	1.7	0.194			
Wiik et al. [20]	Speed (km/h)							7.0 (0.6)	6.2 (0.8)	< 0.05
	Cadence (step/min)							133 (16)	139 (13)	NS
	Heel Strike Force (BW)							1.52 (0.11)	1.38 (0.18)	< 0.05
	Mid-stance force (BW)							0.58 (0.13)	0.67 (0.13)	< 0.05
	Toe-off force (BW)							1.01 (0.13)	1.01 (0.14)	NS
	Step length (cm)							92 (9)	87 (10)	< 0.05
	Stride length (cm)							189 (29)	172 (20)	< 0.05
	Impulse (BW/s)							0.45 (0.03)	0.48 (0.03)	< 0.05
	Stance time(s)							0.56 (0.03)	0.60 (0.04)	NS
	Gait width (cm)							12.6 (2.7)	12.6 (3.8)	NS

Table 3 (continued)

Authors	Outcome parameters	Preoperatively			6 months postoperatively			1 year postoperatively		
		UKA mean (SD)	TKA mean (SD)	*P*-value	UKA mean (SD)	TKA mean (SD)	*P*-value	UKA mean (SD)	TKA mean (SD)	*P*-value
Igor Komnik et al. [21]	Velocity (m/s)							1.4 (0.03)	1.4 (0.03)	NS
	Contact time (s)							0.68 (0.03)	0.68 (0.03)	NS
	Step length (cm) S							38.9 (1.5)	39.1 (2.3)	NS
	Step width (cm)							4.7 (1.7)	4.6 (1.2)	NS
	Varus angle (°)内翻							2.4 (1.4)	2.4 (0.8)	0.897
	RoM angle (°)							2.1 (1.2)	1.9 (0.6)	0.976
	Int. rotation angle (°)							4.5 (5.4)	0.49 (2.8)	0.103
	Adduction moment [Nm/(kgm)]							0.32 (0.08)	0.27 (0.05)	0.109
	Internal rotation moment [Nms/(kg m)]							0.09 (0.04)	0.07 (0.02)	0.378
	Adduction mom. impulse [Nms/(kg m)]							0.05 (0.02)	0.04 (0.01)	0.101
	Joint stiffness (Nm/°)							0.007 (0.002)	0.006 (0.001)	0.068
	FAP-CoMadd (cm)							35.6 (5.6)	33.9 (8.4)	0.503
Jones et al. [22]	Top walking speed (m/s)							2.2	1.6	$p < 0.001$
Anatole V et al. [23]	Speed (m/s)							1.75	1.52	$p < 0.05$
	Hof speed (H)							0.59	0.51	$p < 0.05$
	Cadence (step/min)							134.9	133.9	NS
	Step length (cm)							85.6	75.2	$p < 0.05$
	Stride length (cm)							173.2	150.2	$p < 0.05$
	Contact time (s)							0.58	0.60	NS
	Step time (s)							0.44	0.45	NS
	Single limb stance (s)							0.31	0.33	NS
	Gait width (cm)							13.2	13.6	NS
S Miller et al. [16]	Cadence (steps/min)							105.193	102.190	0.270
	Gait speed (m/s)							1.054	1.011	0.307
	Stride length (m)							1.200	1.188	0.719
	Stride time (s)							1.152	1.196	0.197
	Step length (m)							0.599	0.600	0.953
Cankaya et al. [25]	Gait velocity (m/s)							1.2735	1.1621	0.003
	Cadence (steps/minute)							102.0588	103.2218	0.727
	Step time (s)							592.0000	594.7429	0.807
	Step length (cm)							60.0000	61.6062	0.302
	Step time symmetry							13.5453	20.0606	0.005
	Step length symmetry							16.3041	21.6932	0.024
	Vertical COM							1.0529	1.1176	0.609

Abbreviations: NS, Not Significant

enhanced quadriceps contraction efficiency post-surgery, leading to significant improvements in stride length and cadence compared to their preoperative status [32]. These improvements reflect substantial functional gains in hip flexion and knee extension. Notably, UKA patients exhibit greater improvements in stride and step length than TKA patients, attributable to two main factors. Firstly, pain relief plays a pivotal role in increasing stride and step length [33]. As pain subsides, patients encounter fewer gait restrictions during the support phase, allowing for smoother weight transfer and more fluid gait patterns. In essence, reduced pain enables larger, more confident steps, directly enhancing step length. Given that UKA has shown better outcomes in pain reduction, its effects on stride and step length are more pronounced. Secondly, compared to TKA, UKA patients retain a more

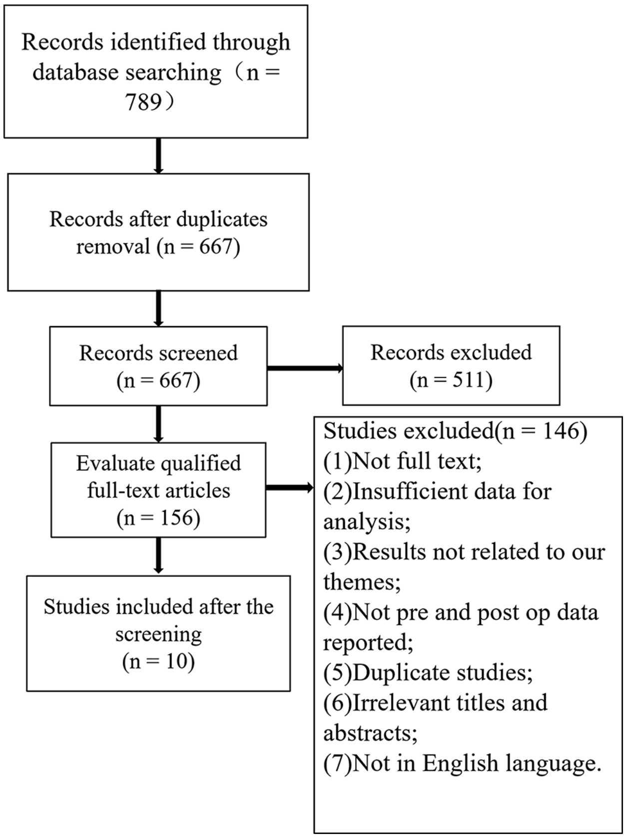

Fig. 1 Search strategy results

natural movement pattern and exhibit superior proprioception. This preservation of natural gait mechanics results in more confident movements and a gait pattern that is closer to preoperative norms, leading to better coordination and synchronization of body movements.

Single support time is a critical gait analysis indicator for evaluating lower limb stability and balance [34], reflecting the ability to support body weight on one leg during walking. A longer single support phase generally indicates better muscle strength, joint stability, and balance, which are essential for enhancing quality of life and reducing fall risk. Friesenbichler's study found that six months post-surgery, the UKA group demonstrated a longer single support time compared to the TKA group [19]. This phenomenon may be explained by three factors: first, the reduced postoperative pain associated with UKA may facilitate an earlier return to normal gait; second, UKA patients typically retain greater leg muscle strength, aiding in more stable weight support during walking; and third, the preservation of the anterior and posterior cruciate ligaments in UKA plays a key role in maintaining knee stability, potentially contributing to longer single support times during the gait cycle.

Wiik's study indicated that one year post-surgery, the UKA group exhibited a smaller minimum knee flexion angle during the stance phase than the TKA group, suggesting that UKA patients achieved near-complete knee extension during walking. Additionally, the UKA group demonstrated a greater range of knee motion and higher maximum knee flexion during the stance phase compared to TKA patients [24]. These results imply that UKA patients possess stronger knee flexion support, consistent with the widely held view that muscle strength loss is minimal after UKA and that knee flexion stability is superior [35]. The greater ROM observed in UKA patients during the gait cycle is also noteworthy [17], which can be attributed to the procedure's targeted approach of replacing only the damaged compartment while minimizing disruption to surrounding soft tissues. This technique helps preserve the original tension and balance of the joint, significantly reducing the likelihood of postoperative adhesions. These factors not only create favorable conditions for functional rehabilitation but also lessen the need for substantial alignment adjustments, ultimately enabling UKA patients to achieve superior active ROM post-surgery.

Nishizawa's study reported that the knee flexion angle at heel contact in UKA patients was significantly smaller than in TKA patients [17]. This variation in knee flexion at initial contact likely reflects differences in joint mobility characteristics between UKA and TKA post-surgery. Specifically, the smaller flexion angle in the UKA group suggests that the knee can achieve and maintain full extension more easily during movements such as kicking, which may facilitate better quadriceps recovery and strength preservation. Further analysis indicates that the reduced knee flexion at heel contact could be closely associated with quadriceps strength. Stronger quadriceps recovery post-UKA may make knee extension during leg movements more accessible. However, quadriceps strength recovery is a multifactorial process influenced by the surgical technique, postoperative rehabilitation protocols, and individual patient characteristics [36]. To effectively enhance the strength of the quadriceps, we recommend the initiation of isometric contraction exercises in the early postoperative stage. This training method requires patients to contract the muscle without changing the joint angle, thereby strengthening the quadriceps and accelerating muscle function recovery. Next, straight leg raises can further train the quadriceps, significantly enhancing its contraction efficiency and providing solid support for knee stability and strength. As rehabilitation progresses, we can moderately increase the difficulty and intensity of training by adding resistance tools such as resistance bands and sandbags. These exercises can more efficiently improve quadriceps strength, which lays a solid foundation for the overall success of postoperative rehabilitation. Moreover, the degree of knee flexion at heel contact may also correlate with the level of pain experienced during knee extension. Reduced pain in UKA patients during extension could encourage more complete knee straightening, resulting in a smaller flexion angle. These results suggest that evaluating postoperative joint mobility and functional recovery requires a comprehensive approach that includes pain management, targeted rehabilitation strategies, and consideration of the patient's subjective experiences.

Peak tibial internal rotation moment (PTRM) and knee adduction moment are key indicators for assessing the rotational stability of the knee joint. Nishizawa's study [17] found that one year post-surgery, UKA patients exhibited significantly higher PTRM than TKA patients, likely due to UKA's ability to preserve knee rotational stability. By retaining most ligaments and soft tissues and replacing only the affected compartment, UKA better maintains the knee's original rotational stability during movement. In contrast, TKA involves replacing the entire joint, potentially disrupting the structures responsible for rotational stability, resulting in lower rotational torque postoperatively. However, it is crucial to acknowledge that abnormal or excessive PTRM can adversely affect the long-term durability of joint prostheses. Specifically, elevated internal rotation moments during walking can increase the medial compartment's load, accelerating prosthesis wear and potentially shortening the joint's lifespan [37]. Compared to the TKA group, the UKA group showed significantly lower peak knee adduction moments during walking at one year postoperatively [17], suggesting several biomechanical benefits. Firstly, UKA patients demonstrated reduced lateral sway and limb swinging during walking, indicating superior muscle control and coordination, which helps to minimize unnecessary energy expenditure and additional joint stress. Secondly, there was less side-to-side shift in their center of gravity, reflecting enhanced balance and reducing excess pressure on the medial knee joint. The gait of UKA patients also appeared more natural, likely resulting from substantial pain relief. As pain diminishes, patients no longer need to alter their gait to avoid discomfort from medial knee pressure, enabling a more efficient and natural walking pattern. This more natural gait not only improves walking comfort but also effectively reduces the peak knee adduction moment, thereby potentially lowering the risk of joint overloading and related complications.

Significant improvements in gait symmetry are essential for enhancing overall stability and balance [38]. During walking, any discrepancies in step timing or length between the legs can directly affect the stability of the body's center of gravity, significantly increasing the risk of falls. Cankaya's study [25] reported that UKA patients achieved substantial improvement in step time and step length symmetry within one year postoperatively. This enhanced gait symmetry enabled UKA patients to maintain a more stable posture during walking, effectively reducing unnecessary energy expenditure and significantly improving walking safety and efficiency. Moreover, gait asymmetry can have a profound impact on load distribution within the knee joint, potentially leading to uneven stress across the medial, lateral, or anterior-posterior regions, posing a risk to joint health [39]. Failure to restore gait symmetry postoperatively may result in additional stress on healthy joint tissues, accelerating degenerative changes or causing new pain or injury. Specifically, when the affected limb cannot bear weight normally due to surgery or injury, the body naturally shifts its centre of gravity to the healthy side to maintain balance. This shift places additional pressure on the healthy knee joint, which, over time, accelerates wear and significantly increases the risk of degenerative changes. Simultaneously, due to insufficient activity and exercise during the postoperative recovery period, the degenerative process of the affected knee joint also subtly accelerates. Gait asymmetry profoundly impacts joint range of motion and flexibility [40]. The affected limb struggles to fully extend and flex while walking, directly limiting the joint's range of motion. This limitation not only significantly weakens the patient's walking ability but may also exacerbate joint stiffness and muscle atrophy. Over time, prolonged activity restriction triggers a series of cascading effects, including muscle weakness and reduced joint stability, further deteriorating joint condition. Ultimately, joint stiffness and muscle atrophy lead to a marked decline in the joint's loadbearing capacity, making it more susceptible to degenerative changes during daily activities. In contrast, restoring gait symmetry promotes more even load distribution across the joint, alleviating pressure on specific areas and providing a solid foundation for the long-term use of joint prostheses. As the population of younger patients with knee osteoarthritis grows, with increasing functional demands post-surgery, achieving optimal gait symmetry has become a critical rehabilitation goal. The immediate initiation of a postoperative rehabilitation plan, meticulously designed and guided by professional physiotherapists, accelerates the recovery of joint range of motion through a series of scientific functional exercises. This approach effectively alleviates postoperative adhesions and stiffness and lays a solid foundation for restoring gait symmetry. Meanwhile, balance training plays an equally crucial role. Through carefully structured exercises like weight shift drills and single-leg stands, patients experience significant improvements in stability, reducing the risks of postoperative gait instability and falls, which further enhances gait symmetry. Additionally, to expedite patients' re-integration into daily life, activities simulating everyday movements, such as stair climbing and walking, can be incorporated into the rehabilitation plan.

These exercises not only help patients gradually adapt to normal gait patterns but also greatly promote a comprehensive and rapid recovery of gait symmetry. This goal is essential for improving overall quality of life and facilitating full postoperative recovery.

This study has several limitations. First, the sample size of UKA and TKA patients is relatively small, and prospective studies in the current literature are underrepresented, which may limit the generalizability and strength of the conclusions. More high-quality studies with larger sample sizes are needed to reinforce and expand the analytical framework. Second, inconsistencies in follow-up durations across the studies may affect the assessment of clinical outcomes, potentially impacting the reliability and comparability of the data. Different follow-up periods may obscure certain treatment effects, complicating result interpretation. A short follow-up period often fails to fully reveal the long-term benefits of treatment, potentially obscuring some therapeutic advantages. For UKA, while TKA may not show pronounced effects in the short-term, its long-term benefits require extended follow-up to become evident. If the follow-up period is insufficient, these long-term benefits may be overlooked, affecting a comprehensive and accurate assessment of treatment outcomes. To more precisely assess the long-term efficacy of treatments, we recommend that future researchers use longer follow-up periods. This approach would help capture effects that may not be evident in the short term but become apparent with extended follow-up and provide more reliable and comprehensive data to support clinical decision-making. Lastly, this review includes only 10 studies focused on changes in gait parameters pre- and post-surgery, which somewhat limits the comprehensiveness and depth of the analysis. As more relevant studies become available, future reviews should incorporate additional high-quality literature to further enrich and enhance understanding in this field.

Conclusions

Although many studies have demonstrated advantages in gait improvement for UKA patients over TKA patients, these benefits have not translated into significant differences in traditional clinical evaluation scores. To improve the reliability and validity of future findings, larger-scale prospective randomized controlled trials are needed. Additionally, it is also recommended to integrate the latest artificial intelligence tools, such as sensors and cameras, to capture motion data as patients walk. Using AI algorithms for analysis, we can evaluate parameters like gait abnormalities, stride length, walking speed, and joint range of motion, providing an objective assessment of the impact of UKA and TKA surgeries on patients'walking function. By comparing pre-operative and post-operative gait data, we can quantify surgical outcomes and guide rehabilitation training. Such an approach would enable a more comprehensive analysis of the specific effects of UKA and TKA on patients' daily walking function.

Abbreviations

OA	Osteoarthritis
KOA	Knee osteoarthritis
TKA	Total Knee Arthroplasty
UKA	Unicompartmental Knee Arthroplasty
ROM	Range of motion
OKS	Oxford Knee Score
KSS	Knee Society Score
WOMAC	Western Ontario and McMaster Universities Arthritis Index
OKS	Oxford Knee Score
VAS	Visual Analog Scale
EuroQoL	EuroQol Group 5-Dimension Self-Report Questionnaire
EQ-5D	EuroQol 5 part questionnaire
NS	Not Significant
PTRM	Peak tibial internal rotation moment

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