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Case Report

Functional Outcome Measures and Patients' Satisfaction following Primary Total Knee Arthroplasty, a Systematic Review

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Abstract

Background and Objective: Commonly, only different types of patient-reported outcome measures (PROMs) are used to measure outcomes post-total knee arthroplasty (TKA), despite their limitations. This review's objectives were to: assess the psychometric properties of commonly used PROMs and other objective tools to measure function post-TKA, such as: Performance-based Outcome Measure (PBOMs), Star Excursion Balance Test (SEBT) and accelerometers to measure physical activity. In addition to assess the tools used to measure patients' satisfaction post-TKA.

Methods: A systematic review was conducted to investigate the available methods for measuring TKA outcomes. The psychometric properties of each method were reviewed to recommend the best tools to capture accurately improvements in function and satisfaction post-TKA.

Results and Conclusions: KOOS and OKS showed good reliability, validity and sensitivity with a post-TKA population. However, patient function is multidimensional and requires more than just a questionnaire. Therefore, it is recommended to use other objective methods in addition to PROMs, such as PBOMs, SEBT and reliable accelerometers to paint a detailed and accurate overall recovery picture post-TKA. Four of the five PBOMs tests recommended by the Osteoarthritis Research Society International (OARSI) showed excellent to good psychometric properties with a post-TKA population. ActivPAL show good reliability and had advantages over other accelerometers in its ability to accurately measure both volume- and event-based patterns. Using one question with different options to answer to assess satisfaction is not accurate and so it is recommended to use satisfaction tools that cover each issue in isolation to better understand the impact of each factor on satisfaction.

Keywords: Knee Arthroplasty; Patient-Reported Outcome Measures; Performance-Based Outcome Measures; Star Excursion Balance Test; Free-Living Physical Activity; Satisfaction

Introduction

Individuals with end-stage knee osteoarthritis (KOA) complain that pain persists at rest and at night, which may disturb sleep, in addition to a marked and limited range of motion. Pain and limited movement are major sources limiting physical activity (PA), and subsequently chronic disability [1]. Total knee arthroplasty (TKA) is a cost-effective treatment option for end-stage KOA and the procedures rate is increasing due to high functional demands in an ageing society [2,3]. TKA success has traditionally been evaluated from the surgeon's perspective, e.g. the presence of surgical complications or implant survival. This is gradually changing to involve the patient when measuring health outcomes and decision-making processes. Patient-reported outcome measures (PROMs) have evolved in order to better explore patient perspectives by monitoring the quality of care in health organisations and conducting clinical trial outcomes [4]. However, subjective over/underestimation and recall bias of PROMs cannot be excluded. So, further objective methods are commonly used post-TKA, such as assessments of functional performance, balance and PA. Each assessment method has its strengths and limitations; therefore, the aim of this review was to systemically identify, appraise and synthesise available studies to determine proper outcome measurements methods to assess outcomes post-TKA.

Materials and Methods

Search strategy

In accordance with PRISMA (Preferred Reporting Items for Systematic reviews and Meta-Analyses) guidelines, a systematic review of the literature was conducted electronically, making use of several medical databases including: Cumulative Index to Nursing and Allied Health Literature (CINAHL), Medline/ PubMed, PEDro, Cochrane Library, Cochrane Central Register of Controlled Trials (CENTRAL), ProQuest, TRIP and Google Scholar. To define the search strategy, the PICO (Population, Intervention, Comparison and Outcome) framework was used. The keywords and terms used are shown in Figure 1 and 9. The search was limited to research published in English between 2004 and May 2020 on human adult participants and with full access to articles. Unpublished studies were not included because they are rarely peer-reviewed.

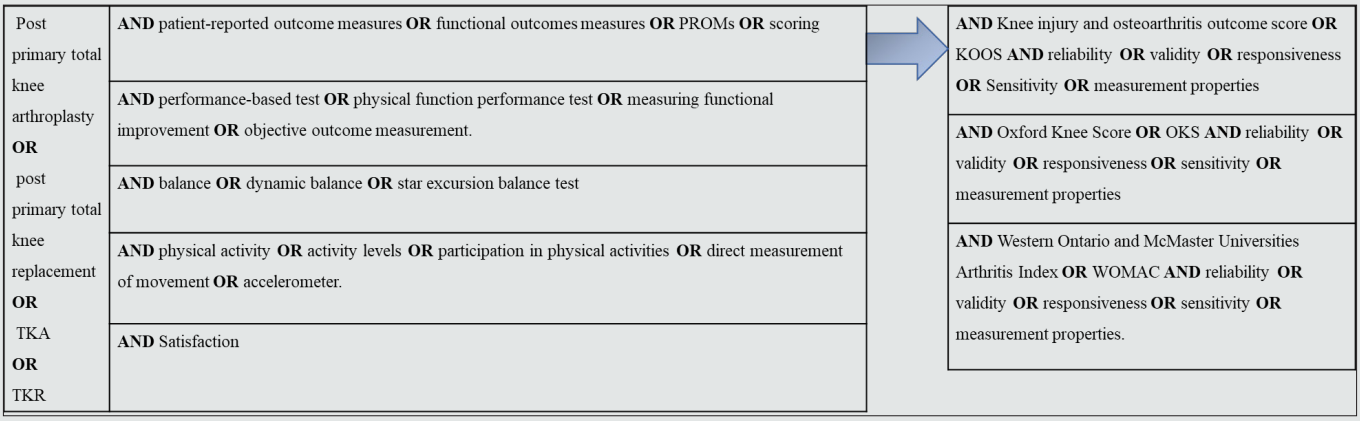

Figure 1: The keywords and terms used for systematic review.

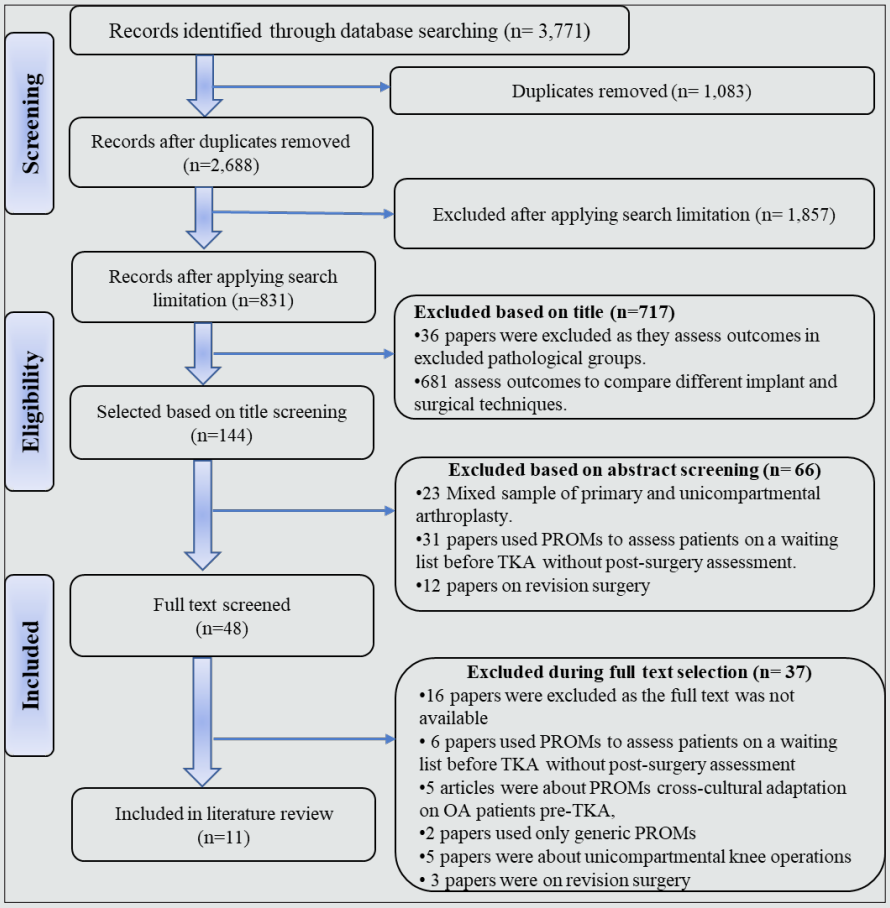

Figure 2: PRISMA 2009 Flow Diagram for Patients Reported Outcome Measures Post-Total knee arthroplasty.

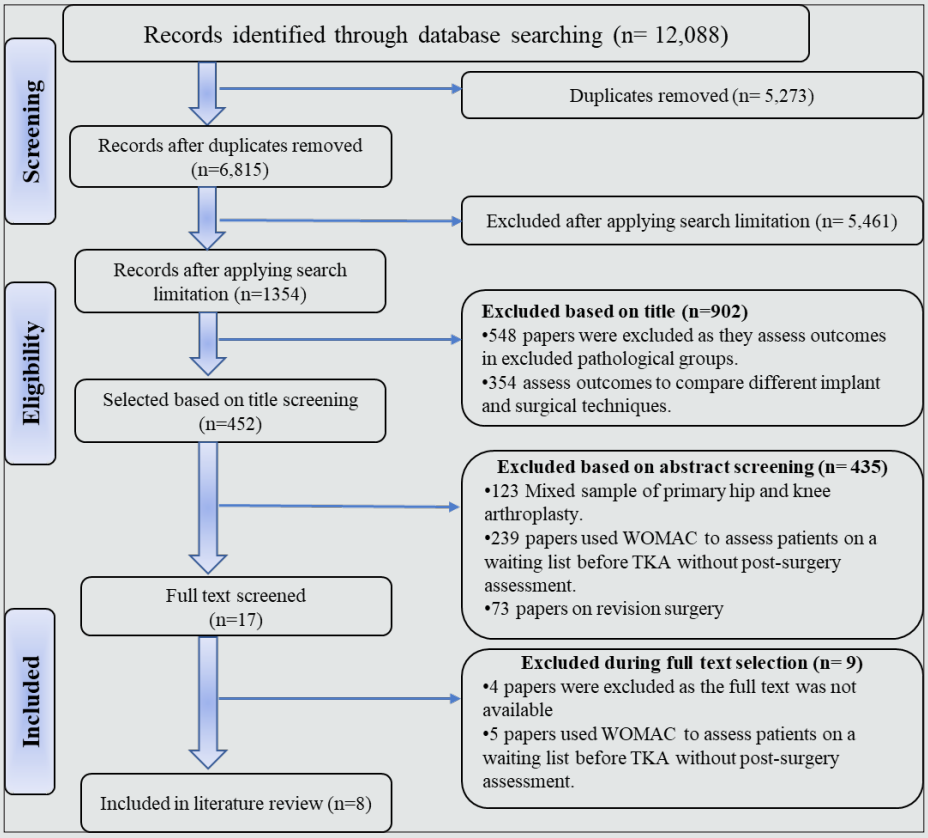

Figure 3: PRISMA Flow Diagram for Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC) Post-Total knee arthroplasty.

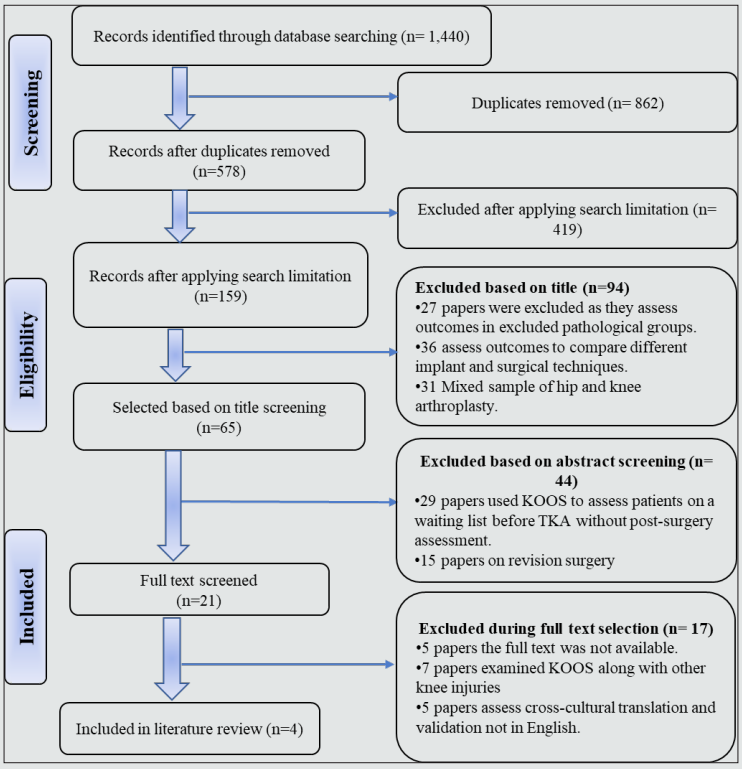

Figure 4: PRISMA Flow Diagram for Knee Injury and Osteoarthritis Outcome Score (KOOS) Post-Total knee arthroplasty.

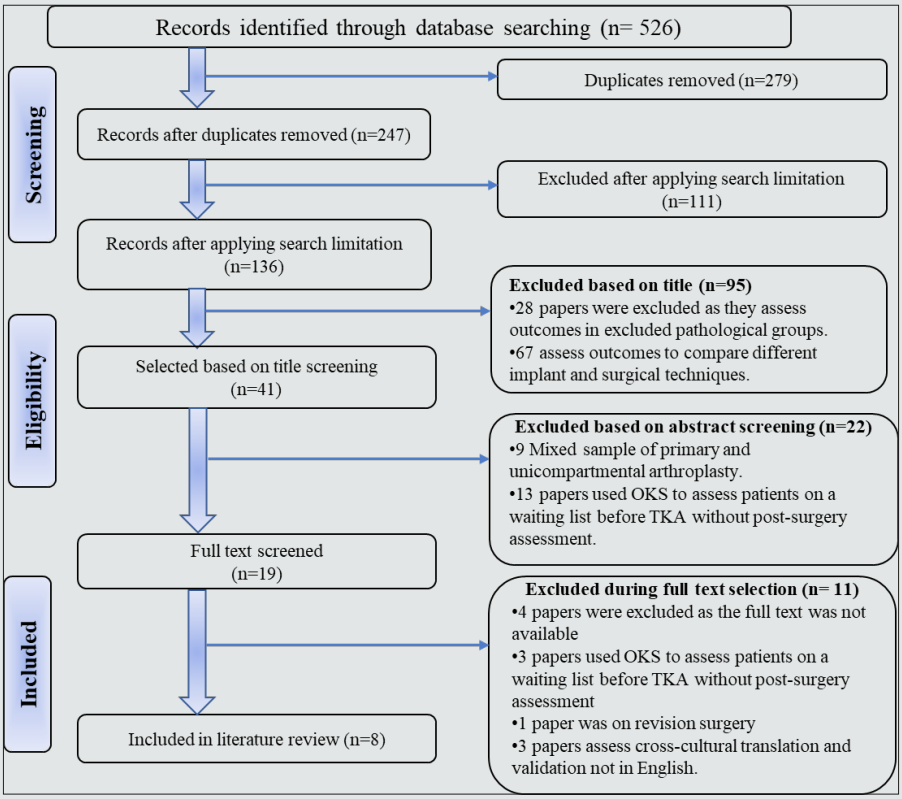

Figure 5: PRISMA Flow Diagram for Oxford Knee Score (OKS) Post-Total knee arthroplasty.

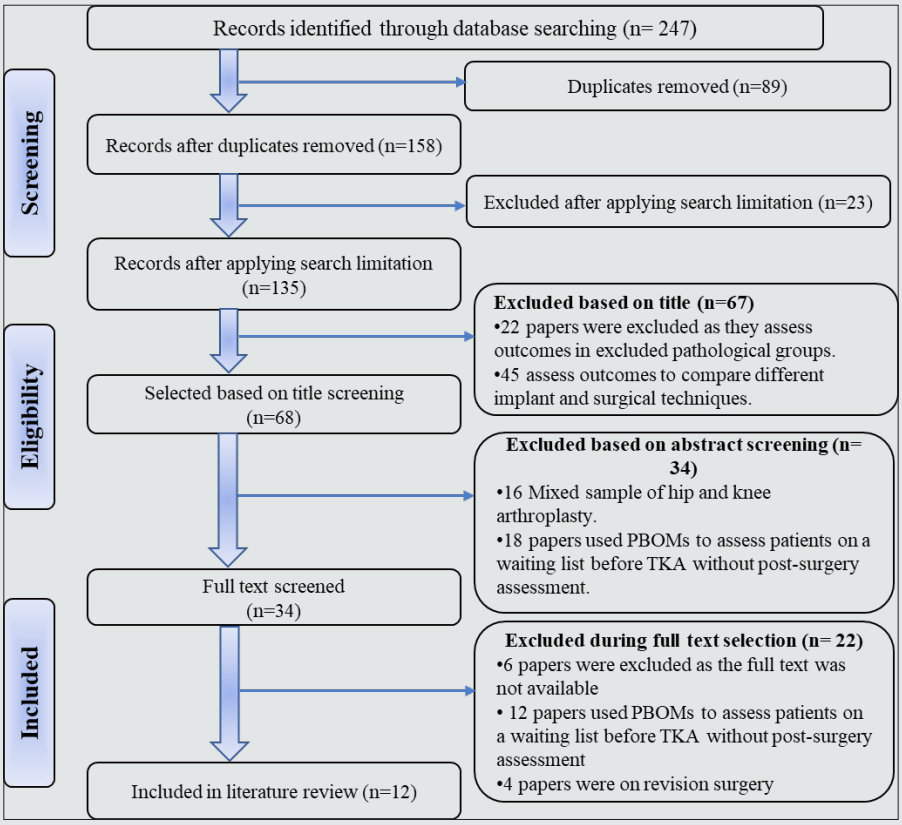

Figure 6: PRISMA Flow diagram for Performance Based Outcome Measures.

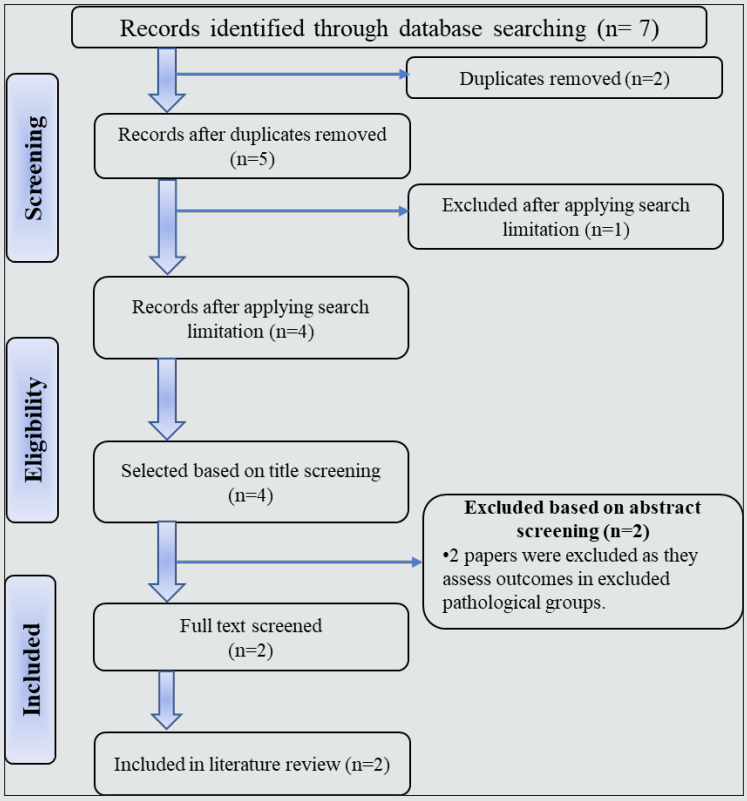

Figure 7: PRISMA Flow diagram for Star Excursion Balance Test (SEBT).

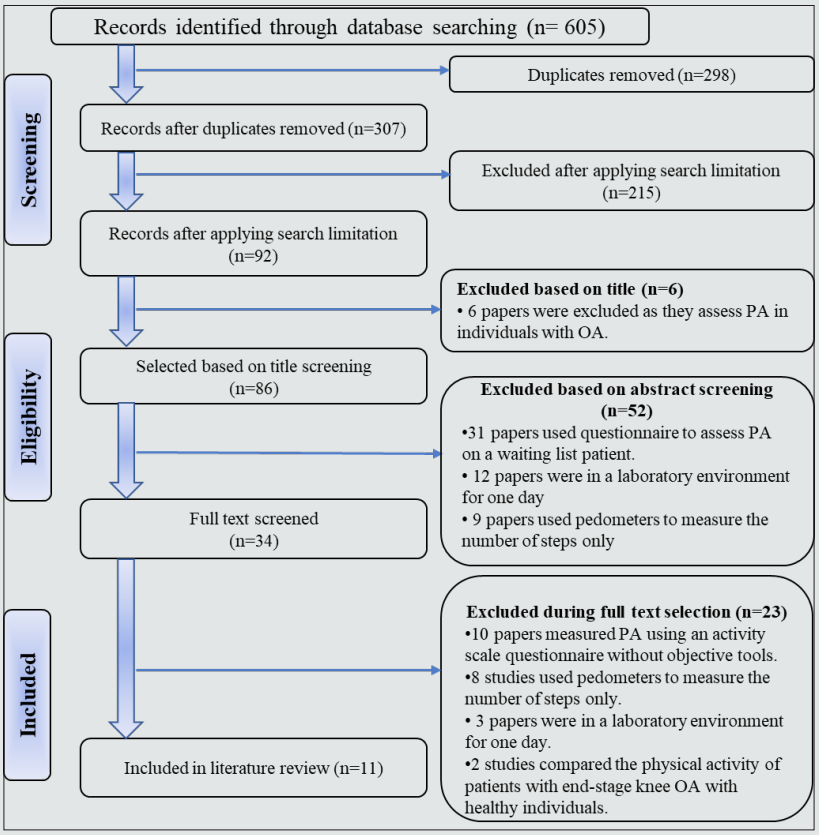

Figure 8: PRISMA Flow Diagram for Physical Activity.

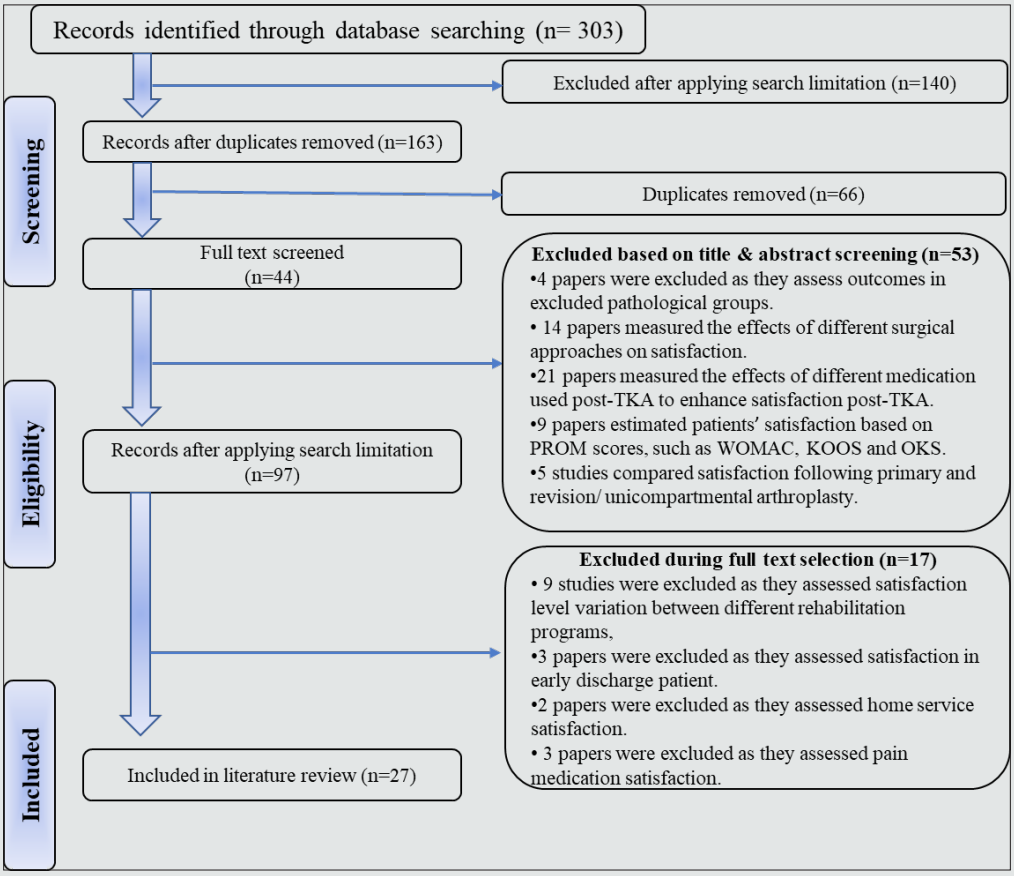

Figure 9: PRISMA Flow diagram for patients' satisfaction post-Total Knee Arthroplasty.

Eligibility Criteria

Studies were included if they satisfied: any study methodology measuring outcomes post-primary TKA in terms of PROMs alone or combined with patient performance-based tests, dynamic balance, physical-activity measuring devices and satisfaction. However, any study assessing an outcome other than after primary TKA was excluded, such as: post-traumatic and revision TKA outcome measurements, unicompartmental knee-replacement, TKR in pathological groups, such as neurological disorders (stroke, Parkinson's disease etc.), and post-TKA outcomes based on implant survival, surgical techniques, complications, engineering metallurgic issues and radiographic or any other outcomes not patient generated. Reference management software (Endnote X7) was used to merge results and remove duplicates.

Critical appraisal of risk of methodology bias

Study quality was appraised using CASP (Critical Appraisal Skills Program) and a suitable study-design tools checklist (CASP, 2007) according to two independent reviewers. The CASP tool assesses three main aspects of a research paper: the validity of a study, the quality of the reported results and the value of the conclusions drawn. Positive items (YES) were calculated to estimate the total CASP score and thus assess a study's internal validity and bias potential. A study with a high positive (YES) score was considered to have low bias risk, and a study with one or more key domains with a negative score (NO) was considered to have high bias risk and so its conclusion was interpreted carefully [5].

Results

Outcomes measurement post-surgery is variable and there are many patient factors that may influence outcomes. Each outcome measure in the literature was assessed independently.

Patient-reported outcome measures (PROMs)

Generic PROMs, such as short forms (SF-36, SF-12) and the EQ-5D questionnaire, provide crucial global assessments of outcomes post-TKA, rather than specific isolated evaluations of pain, satisfaction or function. Generic PROM methods are limited to assessing the specific details required for various disease populations, which may decrease their sensitivity, maximise ceiling effects and produce type-2 errors in hypothesis testing. Specific PROMs address issues pertinent to health-related quality of life in relation to a specific pathology or intervention in order to improve sensitivity, better detect changes and minimise ceiling effects [6]. A

PRISMA search strategy for PROMs is summarised in Flow Diagram 2. Six systematic reviews and four prospective cohort studies, as well as a committee survey report from ISAR (International Society of Arthroplasty Registries), reached comparable conclusions; Knee injury and Osteoarthritis Outcome Score (KOOS), Oxford Knee Score (OKS) and the Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC) are the PROMs most commonly used for assessment post-TKA [4,7,8,9,10,11,12,13, 14,15,16]. It is hard to conclude that there is one best or gold standard for specific PROMs for patients post-TKA from the available evidence, thus in-depth analysis is recommended to explore the PROMs' (KOOS, OKS, WOMAC) validity, reliability and responsiveness, with details of the function-assessment strengths and limitations of each one (summarised in Table 1). Therefore, this includes any study assessing the measurement properties of WOMAC, KOOS or OKS in patients undergoing TKA at any point in time post-TKA for adult subjects, without any limitation regarding publication date, in order to explore original developments in PROMs.

Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC)

WOMAC is a commonly used specific PROM for lower-limb dysfunction, it has been used for over 30 years, with different patient pathologies, to evaluate changes in patients' status post-therapeutic intervention. Originally, it assessed pain, joint stiffness and physical function in osteoarthritis hip/knee patients.

A PRISMA search strategy for WOMAC is summarised in Flow Diagram 3. Eight studies assessed WOMAC with post-TKA patients, as summarised in Table 2 [6,17,18,19,20,21 ,22,23]. It was originally validated for knee and hip osteoarthritis patients within a double blinded randomized study investigating the effects of two different types of anti-rheumatic drugs on osteoarthritis hip/knee patients [24]. Pain, stiffness and physical functions fulfil the criteria required for content, construct and face validity. WOMAC is a reliable and responsive PROM for osteoarthritis. Cronbach's alpha for pain, stiffness and function were, respectively, 0.86–0.89, 0.90–0.91 and 0.90. Test-retest reliability with a one-week interval was 0.68 for both pain and function and 0.48 for stiffness [24]. WOMAC shows moderate to strong validity and excellent physical function-internal consistency with a large effect size post-TKA [6,17,18,19,20, 21,22,23]. It has acceptable pain and stiffness internal consistency, but weak stiffness test-retest reliability. The low sensitivity of WOMAC's stiffness subscale reduces the overall standardized response mean [6,22]. The ceiling effect was higher than the acceptable percentage of 15% [25] at 6, 12 and 24 months [6,19,20]. These weaknesses in WOMAC's tools for a post-TKA population are enough to exclude it as an option for assessment tools (Table 1).

Table 1: The measurement criteria for WOMAC, KOOS and OKS for post TKR population.

Criterion	WOMAC	KOOS	OKS
Length	24 items: 5 pain, 2 stiffness, 17 function (14).	Length 42 items: 9 pain, 5 symptoms, 17 ADL difficulty, 5 sport, recreation and quality of life (5).	Short, 12 items: 5 pain, 7 function (4).
Origin date	1982	1998 evaluation for knee injury & OA (5).	1998 for TKA outcome (4).
Validity for TKA	Construct validity showed moderate to strong correlation with other measurements post-TKA (SF36, Nottingham health profile function scale, range of motion, radiology Kellgren rating) and disability scale (9).	Construct validity shows high correlation between KOOS & SF36. Rs=.62 pain, .48 ADL. Low correlation with mental scores (convergent validity) (7).	Construct validity shows moderate correlation pre-TKA with American knee society (AKS); significant agreement with SF36 & HAQ (4).
Sensitivity/ responsiveness	Response rate at one year 90%	Significant improvement, p<.001, effect size for quality of life 2.86–3.54 at 6/12 months, pain 2.28–2.55 at 6/12 months, sport 1.18–1.08 at 6/12 months, respectively (7).	Effect size 2.19, larger than SF36 (4).
	Effect size 2.25 (8).		
Reliability for TKA	Acceptable ≥ .70 internal reliability for pain and stiffness, excellent ≥ .90-.95 for function. Test-retest reliability acceptable for pain and function, weak for stiffness (11). Correlation coefficients for pain, function and overall score 0.55, 0.50 and 0.55, respectively (13).	ICC post-TKA 0.75 with no significant changes between two measures (7).	Internal consistency: Cronbach's alpha .87 pre-TKA and .93 6 months post.
			Test-retest: r=.92, ± 0–4 points of differences (4).
Time required	11 minutes.	10 minutes (5).	5 minutes.
Accepted missing values	Not more than 5 pain, 2 stiffness, 4 function (14).	Two–six items and substituted by average value for dimensions (6,7).	2 items.

Outcome categories	Improvement in pain & function ≥ 50% & absolute change ≥ 20. Responder if pain/ function/ global ≥ 20%, absolute ≥ 10.	0–100: 0 extreme knee problems, 100 no knee problems.	Excellent >41, Good 34–41, Fair 27–33, Poor < 27. (4).
MCID*	15 points (14).	8–10 points (5), 6-9 points (16)	5 points for 2 groups' estimations, 9,7 points for cohorts & individuals (2,12).
Floor effect	14%.	48% for sport & recreation section (1,7)	7% (1), no effect (15)
Ceiling effect	**6 MONTHS:** 27% for pain, 51% for stiffness (10);	**6 MONTHS:** 15% for pain, 16% for sport,	**6 MONTHS:** 5–14%; **12 MONTHS:** 7–22% (1), no effect (15).
	12 MONTHS: 17% quality of life, 30% pain, 64% stiffness (10).	**12 MONTHS:** 22% pain & 17% for quality of life (1, 7).	
*MCID = Minimum clinically important differences, WOMAC =Western Ontario and McMaster Universities osteoarthritis index, KOOS = Knee injury and Osteoarthritis Outcome Score, OKS = Oxford Knee Score, 1 = Dowsey & Choong, 2013, 2= Beard et al., 2015, 3 = Murray et al., 2007, 4 = Dawson, Fitzpatrick, Murray, & Carr, 1998, 5 = Peer & Lane, 2013, 6 = Roos, Roos, Lohmander, Ekdahl, & Beynnon, 1998, 7 = Roos & Toksvig-Larsen, 2003, 8 = Theiler et al., 1999, 9 = McConnell, Kolopack, & Davis, 2001, 10 = Giesinger, Hamilton, Jost, Holzner, & Giesinger, 2014, 11 = Gandek, 2015), 12 = Clement, MacDonald, & Simpson, 2014, 13 = Bombardier et al., 1995, 14= Dunbar, Robertsson, Ryd, & Lidgren, 2001, 15= Harris et al., 2015, 16=Lyman et al. 2018.			

Table 2: Characteristics of Reliability and Validity Studies for Patient-reported outcome measures (PROMs).

Tools	Author	Subjects	Methods	CASP score %
Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC)	Giesinger et al. 2014, [6]	98 patients - Mean age 68.1 years.	Prospective study assessment at five time points: pre- & 2, 6, 12, 24 months post-TKA. Compares responsiveness of WOMAC, Forgotten Joint Score (FJS-12), EQ-5D, Knee Social Score (KSS) and range of motion (ROM)	18/29,
		49% female		62%
	Bombardier et al. 1995, [17]	Included 826 patients post-TKA. Ages 67–99 years, 71% females 2–7 years post-TKA	Retrospective survey to assess the reliability and validity of WOMAC and SF-36	18/29,
				62%
	Griffiths et al. 1995, [18]	21 patients evaluated pre-/ 6 months post-TKA. Mean age 65 years, 50% females	Compared the relative efficiency (RE) of WOMAC, Health Assessment Questionnaire (HAQ) &Arthritis Impact Measurement Scale (AIMS)	14/19,
				74%
	Dunbar et al. 2001,[19]	3,052 patients post-TKA	Prospective study assessing the reliability and validity of specific PROMs (Lequesne, Oxford-12 and WOMAC)	20/29,
		Ages 57–94 years, 2,511 were females		69%
	Gandek et al. 2015, [20]	76 articles, 6 of them TKA	Review articles for WOMAC's measurement properties	14/16,
				87%
	McConnell	43 articles measuring patient's post-arthroplasty, drug therapy, other surgical and non-surgical interventions	Review article evaluates the reliability, validity and responsiveness of WOMAC with four different knee pathologies	13/16,
	et al. 2001, [21]			81%
	Theiler et al. 1999, [22]	43 baselines, both hip and knee, Complete, only 13 patients post-TKA. Mean age 68 years, 60% females	Correlation study of German version of WOMAC and self-administered Lequesne OA index Post-TKA & -THA follow-up for 1 year	12/19,
				63%
	Escobar et al. 2006, [23]	823 patients included after operations and only 364 complete the 2-year follow-up	Prospective study to evaluate responsiveness,	18/29,
		Mean age 71 years, 75% females	minimal clinically important differences and minimal detectable change.	62%

Knee Injury and Osteoarthritis Outcome Score (KOOS)	Roos et al. 2003, [28]	105 post-TKA (6–12 months)	Prospective evaluation of test-retest reliability and validity	17/19, 89%
		Ages 43–86 years, 39 males and 66 females		
	Sasaki et al.	130 patients post-TKA (16 males, 114 females) 91.4% post-primary TKA 74.0±8.0 years old.	Retrospective study	17/19, 89%
	2014,[29]		2002–2010, Correlation study	
	Davis et al. 2009, [30]	Post THA & TKA, TKA =248	Internal consistency of KOOS-PS.	16/19, 84%
		Mean age 64.5 years, 63% female	Construct validity & responsiveness compared to WOMAC.	
	Lyman et al.2018, [31]	2630 completed KOOS pre-TKA & 2 years post-TKA	Assess the validity of estimates for the minimal clinically important difference (MCID)	17/19, 89%
Oxford Knee Score (OKS)	Hamilton et al. 2012, [11]	183 primary TKA 71 males 112 females Ages 46–92 years. Assessed pre-TKA and at 6, 26 and 52 weeks	Prospective correlation study between OKS and numerical scale functional based outcomes, ROM and strength.	19/28,
				67%
	Beard et al.	94,502, only 60% of them completed both pre-/ 6 months post-OKS. 94,015 completed a global assessment.	Retrospective study estimated minimal important changes and minimal important differences.	21/28,
	2015, [34]			75%
	Clement et al. 2015, [35]	322 TKA, 128 males (37–89 years)	Prospective study to explore threshold values in OKS post-TKA to achieve patients' expectations and satisfaction	22/28,
		194 females (33–91 years)		78%
	Clement et al. 2014, [36]	505 post primary TKA	Retrospective cohort study to estimate minimal clinical important differences in MCID	22/28,
		210 males, 295 females, Ages 39–91 years		78%
	Gen et al. 2015, [37]	Age-matched 217 post-TKA	Prospective assessment of gender effect on short-term outcomes	20/28,
		106 males, 111 females, 2006–2011		71%
	Judge et al. 2012, [38]	Primary TKA =1,784	Pre- & 6 months post, TKA & OKS correlation with patients' satisfaction	21/28,
		2004–2009, Age 17–96 years, 62% female		75%
	Marx et al. 2005, [39]	58 post-primary TKA	Prospective study using MODEMS, WOMAC and OKS	18/28,
		42–90 years, 62% were female		64%
	Matharu et al. 2014, [40]	4,186 patients post-TKA	Retrospective assessment of post-primary TKA data OKS. 1997–2001 pre-/ post-surgery to assess the long-term responsiveness post-TKA.	16/28,
		61% females. Average age 69.2 years		57%

Knee Injury and Osteoarthritis Outcome Score (KOOS)

KOOS is an extension of WOMAC, which has remained unchanged since 1998. The main purpose of KOOS is to measure short- and long-term follow-up of patients' opinions about their knee and accompanying problems, with good coverage of function in terms of joint mobility, stability, stiffness, pain sensation, activities of daily living, sport, recreation and knee-related quality of life, as the intended population is the young and middle-aged with post-knee injuries or trauma and patients with KOA. Its main strong point is a short function score which covers functional requirement assessment suitable for active participants while minimizing the ceiling effect [9, 26, 27]. A PRISMA search strategy for KOOS is summarised in Flow Diagram 4. Four studies assessed the psychometric properties of KOOS with post-TKA patients, as summarised in Table 2. KOOS is a valid, reliable and responsive assessment tool for patients post-TKA, it has certain advantages over WOMAC and OKS, especially in groups with high PA expectations and for young subjects [28,29,30,31]. Also, it evaluates knee-related quality of life, which is a crucial issue for the majority of patients post-TKA, something not covered by WOMAC or OKS [28]. All four studies concluded that KOOS has sufficient validity and reliability post-TKA [28,29,30,31]. Special consideration is required if KOOS is used for a 12-month follow-up as the ceiling effect reaches 22% on the pain scale and 17% for quality of life [28], which are above the acceptable ceiling effect percentage of 15% [25] (Table 1). Hence it is recommended to use other measurement scales for patient quality of life and expectations, rather than KOOS [29].

Oxford Knee Score (OKS)

A final version of a 12-item questionnaire was developed to assess patients post-TKA after interviews with patients undergoing joint replacement and a multiple drafting process to identify their experiences and problems post-TKA since 1998 [32]. The main objective of the questionnaire was to measure the patient's perspective on outcomes post-TKA in a short, reliable, practical and valid way, with good sensitivity to important clinical changes. The questionnaire elicited data on recall symptoms in the previous four weeks. It assessed the severity of pain and the ability to engage in the basic daily activities of living [32, 33]. A PRISMA search strategy for OKS is summarised in Flow Diagram 5. Eight studies assessed the psychometric properties of OKS with post-TKA patients, as summarised in Table 2. OKS is a valid, reliable and responsive assessment tool for the period post-TKA, it has certain advantages over WOMAC and KOOS, as it simple and short. As a PROM's main concern is to explore outcomes from the patient's perspective, OKS has the advantage of offering clear MIDC values for all types of studies and is designed to ensure that the results are recognized by patients, in addition to statistical differences, and this may improve the power calculation [11,34,35,36,37,38,39,40]. The ceiling effect is more than acceptable at 12 months follow-up [39], as is KOOS [25] (Table 1). In contrast, OKS does not assess knee-related quality of life and recreation as KOOS does.

Functional performance

The assessment of daily and overall PA is essential, as the proportion of young patients undergoing TKA is increasing, and it is important for assessments to be compatible with a core set of definitions and the International Classification of Functioning, Disability and Health definitions of the World Health Organization [8]. Also, PROM results cannot exclude a research participant effect (RPE) or subjective over/underestimation due to psychosocial effects or pain from other joints, such as hips or back [41,42,43]. Hence, objective clinical evaluation methods can minimise patients' subjective over/underestimations of outcomes, though RPE cannot be excluded. Objective assessment has some advantages over PROMs, such as a lack of ceiling effects and more precision and responsiveness, and it does not require cultural and language adaptation. In contrast, it is costly and not feasible in clinical practice, thus limited to research centres, and it requires specific in-depth training in its use to ensure reliability. In addition, technically, it is only applicable to small groups, in contrast to PROMs. Many reliable objective measurement tools have been used in populations post-TKA, such as video-motion analysis with a force plate, which offers ultimate functional evaluation [44,45,46]. Performance-based Outcome Measures (PBOMs), a balance test and free-living PA accelerometer are clinically feasible and are less costly assessment tools than video-motion analysis to capture functional improvements post-TKA.

Performance-based Outcome Measures (PBOMs)

PBOMs are sensitive for detecting change, responsive and have a minimal ceiling effect, as well as being feasible. PROMs and PBOM measurement tools assess different aspects of function post-TKA. PROMs mainly assess patients' functional ability beliefs and experiences, while objective functional assessment instruments and PBOM measurement tools evaluate patients' actual ability and function and highly correlate with body impairments [7,47]. A PRISMA search strategy for PBOMs is summarised in Flow Diagram 6. Twelve studies assessed PBOMs post-TKA: Six studies explored the correlation between PBOMs and other outcomes post-TKA [14,47,48,49,50,51], and six studies assessed the psychometric properties of PBOMs in a post-TKA population [52,53,54,55,56,57] (summarised in Table 3). Four of the five PBOMs tests recommended by the Osteoarthritis Research Society International (OARSI) show excellent to good psychometric properties with a post-TKA population. These are: 30 s chair-stand test (30 s CT), 40 m fast-paced walk test (40 m FPWT), a stair-climb test (SCT), timed up-and-go test (TUG) and a 6 m walk test (6MWT) [58], summarised in Table 4. A timed up-and-go test, a valid quick functional assessment tool, a 30 s chair-stand test and a timed up and go and walking test showed good correlation with knee extensor and flexor muscle strength. The stair climb test correlated with knee flexion range of motion.

Table 3: Characteristics of patients' Performance Based Outcome Measurements post-total knee arthroplasty studies.

Author	Subjects	Methods	CASP score %
Mizner et al.	100 patients scheduled for unilateral TKA, Measured before, 1–12 months post-TKA	Short Form-36 Health Questionnaire & Knee Outcome Survey of Activities of Daily Living Scale.	17/19, 89%
2011, [14]		Timed Up and GO test, Stair Climbing test, 6 -minute walk test, knee girth, ROM and strength	
Skoffer et.al	Fifty-nine patients, mean age 70.4 years, 6 weeks before TKA.	Associations between muscle strength, measured functional performance (30 s chair-stand test, timed Up-and-Go, 6MWT and 10 m walking test) and PROM (KOOS).	17/19,
2015, [47]			89%
Mark-Christensen et al. 2019, [48]	Outcome measures were collected for 36 patients at baseline (pre-TKA) and 4 months post-TKA	performance-based function improved only slightly by the 4-month follow-up less than PROMs	17/19,
			89%
Naili et.al.	28 patients with knee OA, mean age of 66 years, 25 age- and gender-matched controls participated	3-dimensional gait analysis to measure kinematic and kinetic gait deviations, respectively.	16/19,
2016, [49]		Five Times Sit-to-Stand (5STS) test, KOOS, at baseline prior to surgery and 1 year after TKA.	84%

Aalund et al. 2013, [50]	39 unilateral TKA	Correlation study between isometric knee extension, leg press power, 30 s chair-stand test, 10 m walking test WOMAC and OKS scale	14/19, 74%
Stevens-Lapsley 2011, [51]	39 participants (17 men and 22 women; mean age, 64.0 ± 8.2years	Prospective, randomized using KOOS - SF-36, SCT, TUG & 6MW tests, Quadriceps Strength. Pre-& 1–6 months post	16/19, 84%
Kennedy et al. 2005, [52]	81 patients post TKA	6 MWT, TUG, Stair measure, Fast self-paced walk test SPWT	17/19, 89%
Boonstra et al. 2008, [53]	28 patients measured at 16 months post-TKA and 31 healthy subjects.	WOMAC, Knee Society score & performance-based tests (sit-to-stand movement and timed-up-and-go) were used to assess which of these are selective and valid to measure knee function.	15/19, 79%
Almeida et al. 2010, [54]	43 patients post unilateral TKA (2–6 months)	Interrater Reliability of stair test, two raters measured the time for patients' performance: one standing at top to record STUp and one at the bottom to record STTotal.	18/19, 95%
Hossain et al. 2012, [55]	50 healthy and 50 patients who underwent TKA	Timed horizontal leg hold; Timed single leg stance; Timed 10 m walk; Stride length; Cadence & Step length; Timed 10 step stair; Timed get up and go test; Single hop distance; Triple hop distance, Timed 6 m hop; Kneeling test.	15/19, 79%
Unver et al. 2015, [56]	33 patients at least 6 months post-bilateral TKA	Test re-test reliability study to assess the 50-Foot Walk Test (50 FWT) and 30-second Chair Stand Test (30 CST) in patients who have undergone TKA.	17/19, 89%
Naylor et al. 2016, [56]	158 patients post-TKA	6 MWT pre- and 10, 26 weeks post-TKA and patients' perceived improvement in mobility post-surgery on a 7-point transition scale.	18/19, 95%

Table 4: Measurements Criteria for recommended Performance -Based test by Osteoarthritis Research Society International (OARSI) [1].

	30 s chair-stand test	40 m fast-paced walk test	stair-climb test	timed up-and-go test	6 m walk test
Reliability and validity with TKA* patients	Excellent reliability	NAD**	Reliable to detect deterioration & improvement	Valid & quick initial assessment of global function (6).	Reliable to detect deterioration & improvement
	ICC= 0.92 (2)		ICC = 0.90 (7)	Reliable to detect deterioration & improvement	ICC = 0.94 (7)
				ICC = 0.75 (7)	
Correlation with muscle strength	Good correlation with knee extensor & flexor muscle strength (3). Correlates with leg press strength (4)	NAD	NAD	Good correlation with knee extensor & flexor muscle strength (3).	No correlation between 6MWT & muscle strength (3).
Correlation with knee range of motion	NAD	NAD	Correlates with knee flexion but not with extension (10)	NAD	NAD
Correlation with PROMS	No correlation with KOOS (3)	NAD	NAD	No correlation with KOOS (3)	No correlation with KOOS (3)
Responsiveness	NAD	NAD	Highly responsive in early stage 1-month post-TKA & long-term after 12 months (5).	Highly responsive in early stage 1-month post-TKA & long-term after 12 months (5).	Highly responsive in early stage 1-month post-TKA & long-term after 12 months (5).
Minimum detectable change	1.64 repetition (11)	NAD	2.6–1.9 seconds (10), 5.49 (7)	0.79 seconds (5) - 2.49 seconds (11).	26–55 metres (9)

*TKA = Total knee arthroplasty. **NAD = No Available Data. [1] (Dobson et al., 2013), [2] (Unver, Kalkan, Yuksel, Kahraman, & Karatosun, 2015), [3] (Skoffer, Dalgas, Mechlenburg, Soballe, & Maribo, 2015), [4] (Aalund, Larsen, Hansen, & Bandholm, 2013), [5] (Mizner et al., 2011), [6] (Boonstra, De Waal Malefijt, & Verdonschot, 2008), [7] (Kennedy, Stratford, Wessel, Gollish, & Penney, 2005), [8] (Naili et al., 2016), [9] (Naylor, Mills, Buhagiar, Fortunato, & Wright, 2016), [10] (Almeida, Schroeder, Gil, Fitzgerald, & Piva, 2010), [11] (Alnahdi, 2014).

Balance

Instability in end-stage knee OA is one of the main factors that correlate with disability and a high risk of falling [59,60]. Assessing balance improvement post-TKA is essential to capture functional improvements. Dynamic balance has an advantage over a static based assessment, in that it closely mimics PA demand, as the history of falling in the OA population is seen more during dynamic activities rather than in a static position. Dynamic balance in individuals with OA is commonly assessed using a step test [61,62,63]. The test only assesses dynamic balance in one direction, it does not reflect daily activity balance requirements, and muscular endurance may affect test performance. Dynamic balance may be assessed with another test, i.e. the Star Excursion Balance Test (SEBT). In a SEBT, the individual stands in the centre of the grid and is instructed to stand on the affected or operated leg while reaching out as far as possible in one of three directions with the other lower extremities, and then returns that leg to the centre. The assessor measures the reach distance in each direction, in centimetres, and then normalises the average of the three trials to leg length [64,65]. Thus, this test assesses balance in multiple directions, which may better mimic daily life activity requirements, and it has excellent inter-rater reliability for healthy participants. A PRISMA search strategy for SEBT is summarised in Flow Diagram 7. Two studies used SEBT with knee OA patients, one assessed reliability with early to moderate knee OA and responsiveness after an exercise programme. SEBT showed excellent psychometric properties in early and moderate stages of knee OA [66]. The other study by Al-Khlaifat et al. (2016) found significant improvements in dynamic balance after six weeks of training for knee OA patients, which indicates good sensitivity to detect improvements after an exercise programme [67]. Interestingly, no studies have assessed dynamic balance post-TKA using SEBT or a reliability study with individuals with end-stage OA or post-TKA.

Assessment of free-living physical activity

Although the main outcomes expected after TKA are reduced pain and improved functional performance, there is limited research on overall free-living physical behaviour (PB) outcomes post-TKA. According to the World Health Organisation, physical activity (PA) is defined as any bodily movement that results in energy expenditure by the skeletal muscles. This includes sport, exercise and other activities, such as playing, walking, doing household chores, gardening and dancing. PA has many positive benefits, such as improved cardio-respiratory fitness and enhanced physical and cognitive function. In addition, it lowers the rates of coronary heart disease, high blood pressure, stroke, diabetes, colon and breast cancer, depression and the risk of falling [68]. Many methods are used to assess PA, e.g. direct observation, diaries and questionnaires, though these have subjective limitations and high rates of under/overestimation. In contrast, objective technology analysis, such as foot switches, optical motion analysis, gait mats and force plates, offer a great degree of accuracy, though they have the limitation of being unsuitable for free-living physical activity assessment and so are primarily for laboratory use. Whilst they can collect objective, valid and reliable data to analyse the quality of movements during assessment, they cannot capture the actual quantity and quality of daily life movements [69,70]. Accelerometers have the advantage of offering free-living reliable, feasible and environmentally constrained methods to monitor PA without subjective limitations and reasonable cost when compared to laboratory motion-analysis technology. An accelerometer has the advantage of detecting the intensity and frequency of movements better than a pedometer or actometer [71]. A PRISMA search strategy for PA measured by accelerometers is summarised in Flow Diagram 8. Abstract screening found that 11 papers satisfied the eligibility criteria. Eleven studies assessed PA post-TKA utilizing different types of accelerometers. Three studies used ActivPAL [72,73,74], three used ActiGraph 1GT1M [75,76,77], two used StepWatch Activity Monitor (SAM) [78,79], two studies used an Activity Monitor (AM) accelerometer [80,81], and the last study used hardware introduced by Morlock et al. (2015) [82]; study summaries and quality assessments are presented in Table 5. All accelerometer characteristics and their outcomes are summarised in Table 6. The hardware accelerometer introduced by Morlock et al. [82], the AM accelerometer [80,81], and the ActivPAL [72,73,74] accelerometer assess, in addition to steps per day, the time spent lying, standing and sitting. This accelerometer category –postural classification devices –has the ability to determine the inclination of one or more body segments and drive the body position. The AM and Morlock et al. accelerometers are heavy, which is a disadvantage, at 100 grams and 500 grams, respectively. They consist of three sensors applied to the sternum and one on each thigh. Their heavy weight and multiple sensors require professional application and the patient needs to take it off for sleeping or showering, which may decrease the time it is worn and its feasibility [80,81,82]. On the other hand, ActivPAL had the advantage of being light in weight, at only 20 grams, with one small sensor easily applied to the mid-thigh, and also waterproof. The patient can wear it day and night, which improves the accuracy of measurements [72,73,74] (see Table 6).

ActivPAL has the ability to measure volume free-living PA by considering external environmental confounding factors in addition to patterns of PA and sedentary behaviour. It assesses low-energy positions (sitting and lying) to estimate sedentary behaviour. It also accurately assesses the start time for each position and the duration spent in it. In a similar manner, it estimates upright events (standing, stepping) time in addition to the number of steps and average cadence [83,84]. ActivPAL showed good inter-device reliability, ranging from 0.79 to 0.99. The mean percentage differences between ActivPAL and direct observation of the total time spent sitting and standing were 0.19% (limit of agreement from −0.68% to 1.06%) and 1.4% (limit of agreement from-6.2% to 9.1%) [84] (Table 6). ActiGraph is an energy expenditure classification device that records acceleration in a set time and assign values to estimate acceleration magnitude within a set time period to reflect body movements. It has the ability to estimate

energy expenditure, but may overestimate low-level activities and underestimate vigorous ones. Its ability to detect body posture is limited due to minimal acceleration records when standing, and similarly in a sitting position because it worn at hip level [83,84].

Table 5: Characteristics and limitations for physical activity accelerometers post-Total Knee Arthroplasty Studies.

	Subjects	Methods	Limitations	CASP score %
Lutzner et al. 2014, [72]	97 assessed before and 1-year post-TKA in comparison with 39 age-matched control	ActivPAL measures total steps, moderate to vigorous activity, time spent lying, sitting, standing, walking.	Four consecutive days may not capture activity behavior (recommended to include weekends and weekdays).	15/19,
		Attached over the anterolateral tibia for 4 days, awake and asleep.	The device was applied to the anterolateral aspect of the tibia a position not in compliance to recommendation and a position not previously validated. This may measure the number of steps but cannot distinguish between sitting and standing.	79%

Table 6: Measurements Criteria for commonly used Accelerometers to assess Physical Activities.

	Accelerometer type and sensor placement	Results	Commonly used			
ActivPAL Professional [72,73,74,83,84]	A uni-axial piezoresistive accelerometer. Mid of thigh -worn sensor	Accurately measure the physical behaviour results in 3 categories: sitting/lying, standing and stepping.	Validated for the amount of time spent sitting, lying etc. Shown to be highly accurate for step number and cadence. The monitor also provides data for energy expenditure.	14 days	98%-99%	20 g
		It also measures cadence and number of steps of the user over a day or week.				
ActiGraph GT1M, [75,76,77]	Single-axis piezoelectric accelerometer. Waist or wrist -worn sensor.	The device can measure activity count, steps count, calorie and estimate activity levels across a range of ages and clinical groups.	Energy expenditure classification devices that record acceleration in a set time and assign values to estimate acceleration magnitude within a set time period to reflect body movements. Mainly used with children and adolescents and sleep pattern studies due to its good reproducibility, validity and feasibility within these groups.	14 days	99%	27 g
StepWatch (SAM), [78,79]	StepWatch is a microprocessor-controlled step counter. Ankle -worn sensor	Shows higher estimates of steps per day (>18%) than actual steps taken at slow walking speeds when compared to observational records.	Validated activity monitor for use on healthy, obese, amputees, stroke, spinal injury, young and old	60 days	91–99%	38 g
Activity Monitor (AM), [80,81]	The AM consists of three	Distinguish several postures (standing,	Validated activity monitor for use on persons with a leg	3 days	81-93%	100g
	piezo-resistive accelerometers (about 1.5× 1.5 × 1	sitting, and different forms of lying) and motions (e.g., walking, climbing stairs, cycling)	amputation, students participating in a psychophysiological study, failed back surgery patients, and chronic			
	cm). one sensor on the sternum and one sensor		heart failure patients			
	on each thigh.					
Accelerometer introduced by Morlock et al. [82]	Two inclination	Identify frequency and duration of the activities lying, sitting, standing, walking and stair climbing g from the signals of the 3 sensors. The number of steps walked, and stairs climbed was also calculated.	after total hip arthroplasty and lower limb dysfunction.	4.5–6 hours	79-99%	>500g
	sensors for the thigh and calf and one electro-goniometer sensor positioned at the knee joint					

Patients' Satisfaction

Satisfaction post-TKA is usually linked to functional improvements and pain reduction. Much research attempts to improve the understanding of patients' satisfaction post-TKA, as the degree of satisfaction post-TKA is significantly less than for post-total hip arthroplasty, with up to 20% of patients post-TKA not being satisfied [85,86,87,88,89]. To understand the patient-satisfaction assessment tools used post-TKA, a systematic review of the patient satisfaction post-primary TKA literature was conducted. A PRISMA search strategy was used to devise a transparent article-selection process, which is summarised in Flow Diagram 9. Full-text screening found that 27 papers satisfied the eligibility criteria, these are included and summarised in Table 7. Eleven papers assessed the factors that might affect satisfaction one-year post-TKA [90,91, 92,93,94,95,96,97,98,99,100], seven studies assessed the effect 2–5 years post-TKA [101,102,103,104,105,106,107], one study assessed satisfaction 24 hours after surgery[108], four studies developed predictions for three months and one year satisfaction post-TKA [85,109,110,111], two studies assessed the satisfaction rate at one year post-TKA in Korean and Saudi patients [112,113], one recent study assessed satisfaction with single question correlation with other PROMs [114], and one study assessed satisfaction changes nine years post-TKA [115]. Patients' satisfaction post-TKA is usually measured using one question with different response options on a five-point Likert scale (very satisfied, satisfied, neutral, dissatisfied, very dissatisfied) [90,91,92] , a 4-point Likert scale (very satisfied, satisfied, unsure, dissatisfied) [93,94,95,96] , a visual analogue scale (VAS) for satisfaction [97,98] or by asking patients if they are satisfied with their TKA (and given the options of answering "Yes", "No" or "I'm not sure") [99,100,101]. In conclusion, although patients' overall satisfaction post-TKA is commonly measured using one question with different reply options (binary, 4- or 5-point Likert scales, VAS), this may not accurately assess the reasons behind dissatisfaction. A patient's overall satisfaction may be affected by the hospital experience, surgical complications, pain reduction, functional improvements and expectation achievements. Therefore, it is recommended to use satisfaction tools that cover each issue in isolation and to elicit responses in more depth in order to understand the impact of each factor on satisfaction [112,116].

Table 7: Characteristics and Results of Patients' satisfaction studies Post-Total Knee Arthroplasty Studies.

Author	Subjects	Methodology	Conclusion	CASP score %
Hamilton et al., 2013, [85]	4,709 individuals undergoing primary lower	Overall satisfaction on a four-point scale in addition to satisfaction with five facets (pain, mobility, expectation, sport & experience at one year).	Overall patient satisfaction was predicted by: (1)	25/28
	limb joint replacement		meeting preoperative expectations (OR 2.62 (95% CI 2.24 to 3.07)), (2) satisfaction with pain relief (2.40 (2.00 to 2.87)), (3) satisfaction with the hospital experience (1.7 (1.45 to 1.91)), (4) 12 months (1.08 (1.05 to 1.10)) and (5) preoperative (0.95 (0.93 to 0.97)) Oxford scores.	89%
Lizaur-Utrilla et al., 2016, [90]	192 patients followed for one-year post-TKA	Prospective observational study of patient satisfaction that was assessed on a five-point Likert scale at one post-operative year	Dissatisfaction rate was also higher in patients waiting longer than six months	22/28
			Waiting time longer than six months negatively influenced post-operative satisfaction and patient-related outcome at one-year post-TKA.	79%
Özdemir et al., 2017, [91]	143 patients who underwent total knee arthroplasty using a five-point Likert scale	To ascertain whether a negative affective temperament affects patient satisfaction and outcome measures (pre-/1 year)	No relationship was determined between temperament and satisfaction (P=.734). Overall, the satisfaction rate of the procedure in our patients was 93%.	21/28
				75%
Clement et al., 2015, [92]	322 TKA performed during the study period	Patient satisfaction was assessed using a four-point Likert scale: very satisfied, satisfied, neutral, dissatisfied	Failure to fulfil patient expectations, for 15	24/28
			of the 17 assessed, significantly increased the risk of dissatisfaction at 1 year (p<0.05).	85%
Kim et al., 2010, [93]	Consequently, 387 (372 female and 15	Questionnaire were posted to assess patient satisfaction in Korean patients 1-year post-TKA using a 4-point Likert scale	Dissatisfied patients had more severe functional disabilities than satisfied ones. Dissatisfied patients tended to perceive functional disabilities in high flexion activities as more important than satisfied ones.	17/28
	male) patients (622 knees			61%
Halawi et al., 2019, [94]	276 patients assessed 1-year post-TKA	Patients were contacted via telephone to enquire about their satisfaction with their surgery	The most common reasons for dissatisfaction after TKA were persistent pain (N = 19/46, 41%), functional limitations (N = 12/46, 26%), surgical complications and reoperation (N = 8/46, 17%), staff or quality of care issues (N = 5/46, 11%), unmet expectations (N =2/46, 4%).	
				20/28
				71%

Furu et al., 2015, [95]	28 patients who underwent 30 primary TKAs	Assess the correlation	Postoperative patient satisfaction	19/28
		between satisfaction and muscle strength using the 2011 Knee Society Scoring System	significantly correlated with knee symptoms, functional activity, knee extensor strength and walking status.	68%
Deakin et al., 2018, [96]	1,014 TKA operations were included	To determine and compare the outcomes of non-obese, obese and morbidly obese patients undergoing arthroplasty	In the morbidly obese group, fewer patients were very satisfied, although this was only approaching significance (72% vs 84% and 84%, Chi-squared p =0.054) but there was no significant difference in the numbers of unsure or dissatisfied (3% vs 6% and 6%, p = 0.635).	20/28
				71%
Culliton	Literature review to examine the relationship between expectations and satisfaction in 5 studies. Multivariate analysis of the relation between expectations and satisfaction reported separately for TKA recipients.		Preoperative expectations did not correlate with postoperative satisfaction.	24/28
et al., 2012, [97]	However, postoperative satisfaction was predicted by how well postoperative expectations were met after surgery.		85%	

Risk of methodology bias

The overall critical appraisal results varied for each outcome measurement. PROM study scores range from 89% to 57%, PBOMs from 95% to 74%, PA from 85% to 50% and patient satisfaction from 89% to 57%. PROMs studies' main risks of bias were methods of selection, included patients, randomisation, blindness, not including all subjects in the results without sufficient clarification, ignoring confounding factors in outcome measurements and analyses, and samples mixing different pathologies or interventions. PBOMs studies had less risk of bias and the main limitations concerned randomisation, assessor blindness and similarity of the group baseline. PA studies' main risk of bias was due to the failure to report the psychometric properties of the accelerometer that was used, insufficient details regarding reported outcomes and how they were measured, not considering confounding factors in the results and analysis, limited follow-up post-TKA, no randomisation, the sample selection not representing the population, no blindness, and not all participants completing follow-up. For all outcomes post-TKA, the majority of studies did not consider confounding factors in their results and analyses, which may affect the generalisation of findings. For example, the presence of a previous chronic condition, PA limitation before surgery, a patient's age and psychology may affect the outcome post-TKA and should be considered so as to improve the generalisation of outcomes and improve the understanding of affecting factors. The main limitations of patient satisfaction studies lay in their sampling methods, assessor blindness, follow-up being limited to the short and medium term, using non-validated methods to assess satisfaction, and conclusions based on low levels of evidence which might increase the risk of conclusion bias. The overall risk of bias across the studies ranges from low to high, and high-risk findings should be interpreted with caution.

Conclusion and Future Directions

Primary TKA remains the gold standard treatment for patients with end stage KOA in terms of cost and outcome. The increasing TKA demand across the globe increases the importance of understand patient outcomes following procedures. In general, assessments of PROMs post-TKA focus on function, activity and participation, with limitations in terms of receiving competent care from family, neighbours and healthcare workers, and intimate relationships. In a population younger than 65 years, driving, a return to work and hobbies are limited in all of them. Function and environmental assessment depth differ according to the age of the population post-TKA, as those older than 65 years may require further assessments of mental and physical endurance. A younger population needs more in-depth assessment for a return to work, driving, recreation and sport activity. That may be why there is no available gold standard that covers all the gaps and is suitable for broad age requirements post-TKA, with a suitable balance being struck between complexity and simplicity. Both KOOS and OKS showed good reliability and validity with a post-TKA population. Both of them had similar values for a ceiling effect at a 12-month follow-up. The OKS has the advantage that it is simple and short, has better reliability scores with TKA patients, clear MIDC values and clear outcome categories (Table 2). In contrast, KOOS has the advantage of being more suitable for young patients to assess, in sufficient depth, function, sport, recreation and knee-related quality of life. In terms of the quality of items used to assess symptoms and functional recovery post-TKA, the three commonly used PROMs are compared in depth in Table 2. Striking a balance between complexity, the ability to assess items and maintain sufficient measurement properties is required to achieve comprehensive, valid and reliable outcomes post-TKA. PBOMs are simple and feasible functional tests able to capture different aspects of patient function, they differ from PROMs and do not require any cultural adaptation. They show excellent to good psychometric properties with a post-TKA population. Recommended PBOMs are not multi-item, as in real life, which may affect their ecological validity and leave them prone to RPE [4,42]. In addition, PROMs assess function, sport, recreation and knee-related quality of life, with a risk of subjective under/overestimation. So, inevitably, other measurements are required to overcome this limitation.

Accelerometers are feasible and environmentally constrained methods to monitor free-living PA without subjective limitations and at a reasonable cost when compared to laboratory motion-analysis technology. There is a conflict regarding accelerometer outcomes post-TKA, which may be due to many confounding factors, such as accelerometer measurements not being in a standardized timeline with regard to the timing of TKA and mixed subjects' post-knee and -hip arthroplasty [117,118,119]. In addition, each accelerometer has different outcomes depending on the study objectives and accelerometer placement, such as time spent on PA, rest time, intensity of PA or energy expenditure, which affect the results and conclusion. Interestingly, no study has explored PA in terms of volume patterns with a long follow-up of more than one-year post-TKA to capture the wider picture of PA recovery as is done with PROMs. No study has assessed the reliability and responsiveness of the Star Excursion Balance Rest post-TKA, despite its advantage of closely mimicking PA demand and the history of falling in the OA population that occurs during dynamic activities rather than in a static position. No previous study has assessed the sensitivity of the 30 s chair-stand test and the 40 m fast-paced walk test to detect changes post-TKA.

Table 8: Individual interview findings of Early Patient concerns following total knee arthroplasty and patient reported outcome measures (n = 30) (Rastogi, Davis, & Chesworth, 2007).

	Concern	WOMAC	KOOS	OKS
Body function	Decreasing pain in surgical knee	YES	YES	YES
	Reducing swelling in surgical leg	×	YES	×
	Avoiding infection in surgical knee	×	×	×
	Sleeping better at night	×	×	×
	Increasing bend in surgical knee	×	YES	×
	Increasing straightening in surgical knee	×	YES	×
	Increasing strength in both legs	×	×	×
Activities	Getting out of bed on your own	YES	YES	×
	Getting in/out of a bath	YES	YES	×
	Putting on your own shoes and socks	YES	YES	×
	Dressing yourself	×	×	×
	Walking on a flat surface	YES	YES	YES
	Walking on uneven ground	×	×	×
	Descending stairs	YES	YES	YES
	Ascending stairs	YES	YES	×
	Cooking your own meals	×	×	×
	Doing your own housework	×	×	×
	Heavy domestic duties	YES	YES	×
	Light domestic duties	YES	YES	×
	Getting in/out of a car	YES	YES	YES
	Sitting comfortably in a car	×	×	×
	Doing exercises as prescribed by physiotherapist	×	×	×
Participation	Driving a vehicle	×	×	×
	Going shopping	YES	YES	YES
	Returning to hobbies (e.g. dancing, gardening)	×	×	×
	Going back to regular exercise classes or sport	×	×	×
Environmental factors	Being less of a burden on spouse or caregiver	×	×	×
	Having the support of family members	×	×	×
	Having the support of neighbors	×	×	×
	Receiving competent help from healthcare workers in a timely manner	×	×	×
Total		Nov-32	14/32	May-32

Each outcome measure assesses the outcome post-TKA on a different spectrum. PROMs, PBOMs and accelerometers are valid and reliable tools to evaluate outcomes post-TKA with clear ignorance of personal and environmental factors. These tools' main concern is solely to quantify body impairments and physical ability, without considering other factors. Therefore, a new tool is recommended to explicate the complexity and deeper meaning of patient experience, concerns, functional recovery, outcome expectations and satisfaction post-TKA. More than half of patients' early concerns post-TKA are not considered in commonly used PROMs. Individual interviews with 30 patients post-TKA concluded that 32 patient concerns were not covered sufficiently in KOOS, WOMAC or OKS, as shown in Table 8 [120]. This indicates that current medical outcomes evaluation for intervention implications differ from the patient's perspective. This may be explained by the dissatisfaction of some patients post-TKA. So, more sensitivity to patients' experience of assessment methods is required, in addition to profession-driven tools to paint a full picture of outcomes post-TKA. Therefore, it is recommended to use satisfaction tools that cover each issue in isolation and to elicit responses in more depth to understand the impact of each factor on satisfaction. The main limitation of the current review is its inability to perform a meta-analysis due to the heterogeneity of outcomes across studies. This limited the ability to derive pooled estimations for effect sizes and, overall, obtain clearer findings for each outcome method. However, the minimal detectable changes concluded for PROMs and PROMs clarify expected outcome changes post-TKA. In conclusion, PROMs play a prominent and feasible role in assessing outcomes post-TKA. However, patient function is multidimensional and requires more than a questionnaire. Therefore, it is recommended to use other objective methods in addition to PROMs, such as PBOMs and accelerometers, to capture the accurate overall recovery picture post-TKA in more depth. Furthermore, future research should seek to assess outcomes post-TKA and devise further interventions aiming to increase the amount of PA engaged in by patients having undergone TKA.

Conflict of interest

This research project received no grants or funding from agencies in the public, commercial, or nonprofit sectors. The author has no financial or personal relationships with other people or organisations that could inappropriately influence (bias) this work. There are no other conflicts of interest to declare.

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