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Previous anterior cruciate ligament reconstruction influences the complication rate of total knee arthroplasty: a systematic review and meta-analysis

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- *Purpose:* The results of total knee arthroplasty (TKA) following anterior cruciate ligament (ACL) reconstruction are still under-investigated. The purpose of this research is to investigate the differences between TKA after ACL reconstruction and TKA for primary osteoarthritis through a review and meta-analysis of the literature.
- *Methods:* Case–control and cohort studies reporting outcomes of TKA following ACL reconstruction were considered eligible for inclusion. The primary endpoint was to systematically review and meta-analyze the reported complications of TKA following ACL reconstruction. The outcomes have been compared with a group of patients who underwent TKA for primary knee osteoarthritis (OA) with any previous ACL surgery. Secondary endpoints were to assess and compare technical difficulties and results including the operative time, the use of revision components, the request for intraoperative release or additional procedures, the revision rate, and the clinical outcomes.
- *Results:* Seven studies were included involving 1645 participants, 619 of whom underwent TKA in previous ACL reconstruction and 1026 TKA for primary OA with no previous ACL reconstruction. Meta-analysis showed that TKA in previous ACL reconstruction had a significantly higher complication rate (OR = 2.15, $P < 0.001$), longer operative times (mean differences (MD): 11.19 min; $P < 0.001$) and increased use of revision components (OR = 2.16; $P < 0.001$) when compared to the control group without differences of infection, and revision rate.
- *Conclusions*: TKA in a previous ACL reconstruction has a significantly higher complication rate, longer operative times, and a higher need for revision components and intraoperative soft tissue releases in comparison to TKA for primary OA without previous ACL reconstruction.

Keywords

- anterior cruciate ligament reconstruction
- total knee arthroplasty
- outcomes
- complications
- revision

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Introduction

Anterior cruciate ligament (ACL) injury represents a well-recognized risk factor for the future development of knee osteoarthritis (OA) (1) as instability is a leading cause of cartilage and meniscal damage with a growing incidence over time (2).

Arthroscopic ACL reconstruction is the treatment of choice to restore knee stability (3, 4) and to prevent secondary meniscal tears at long-term follow-up (5, 6). However, the published meta-analysis showed that patients undergoing ACL reconstruction have a higher risk to develop knee OA (1, 5, 6) and the cumulative incidence of total knee arthroplasty (TKA) among patients with a history of ACL reconstruction is seven times greater than the general population at 15 years follow-up (7). The long-term incidence of TKA following ACL reconstruction ranges from 1.1% to 12.2% (6, 7, 8) and due to the current trends in ACL reconstructions (3, 4) orthopedic surgeons will face in the future the need to manage an increasing number of cases of TKA post-ACL reconstruction.

The results of TKA following ACL reconstructions are still under-investigated as only a few researches (9, 10) reported detailed outcomes and complications of this specific cohort of patients.

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The purpose of this systematic review is to meta-analyze the comparative results of TKA in patients with and without previous ACL reconstruction reporting clinical outcomes and complications. Reported surgical challenges are also included in the study. The hypothesis of this research is that patients who underwent ACL reconstruction will have a higher complication rate and longer operative times.

Materials and methods

Literature search and inclusion criteria

This research has been submitted and registered to the international prospective register of systematic reviews, PROSPERO (CRD42022384659).

A systematic review of the literature has been performed, following the Cochrane Handbook of Systematic Reviews of Interventions (11) and Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) (12) for study selection (Fig. 1).

A systematic search from January 1, 1990, to December 1, 2022, was performed in the following databases: the Cochrane Central Register of Controlled Trials (CENTRAL), MEDLINE/PubMed, Embase, Scopus, the Science Citation Index Expanded from Web of Science, ScienceDirect, CINAHL, and LILACS. The research was conducted using the following keywords alone and in all the various combinations: 'ACL,' 'reconstruction,' 'knee,' 'osteoarthritis,' 'TKA,', 'graft', 'BTB,' 'hamstring,' 'quadricep,' and 'allograft.'

English language, cohort, and case–control studies reporting complications and objective and patient-reported outcomes of TKA following ACL reconstruction were considered eligible for inclusion. There was no quality restriction for study inclusion. Case series, case reports, technical notes, editorial commentaries, *ex vivo*, biomechanical, preclinical, and clinical studies without adequate quantitative or qualitative data were excluded. Studies that did not report clear clinical outcomes data were excluded from this research.

Two reviewers (OL, ND) independently screened each title and abstract collected from the primary electronic search. In case of a relevant title and abstract, the full-text version was obtained.

All references of each study were screened to find any additional relevant paper potentially missed with the first review process. The two reviewers independently followed the same checklist to screen all studies and evaluate the eligibility criteria. Disagreements were resolved by consensus agreement with a third reviewer (MAM).

The primary endpoint of this research was to systematically review and meta-analyze the reported complications of TKA following ACL reconstruction including wound complications, stiffness, infection, deep venous thrombosis (DVT), patellar crepitus, patella baja, nerve injury, extensor mechanism damage and reoperation and to compare outcomes with a control group of patients who underwent TKA for primary OA.

Secondary endpoints were to assess and compare the operative time, the use of revision components (stems or constrained implants), the request for intraoperative release or additional procedures (i.e. tibial tuberosity osteotomy and quad snip), the revision rate, and the clinical data (range of motion and clinical scores).

Appraisal of studies' quality and risk of bias

The level of evidence of included studies was evaluated through the adjusted Oxford Centre For Evidence-Based Medicine 2011 Levels of Evidence (13). The quality of the studies was defined using the Grading of Recommendations Assessment, Development, and Evaluation (GRADE) system (14), rating the quality of evidence in systematic reviews.

The risk of bias was classified using the Methodological Index for Non-Randomized Studies (MINORS) (15). Each item of the MINORS was scored 0 when absent, 1 when present but inadequate, and 2 when present and adequate. The ideal score for comparative studies was 24 and 16 for

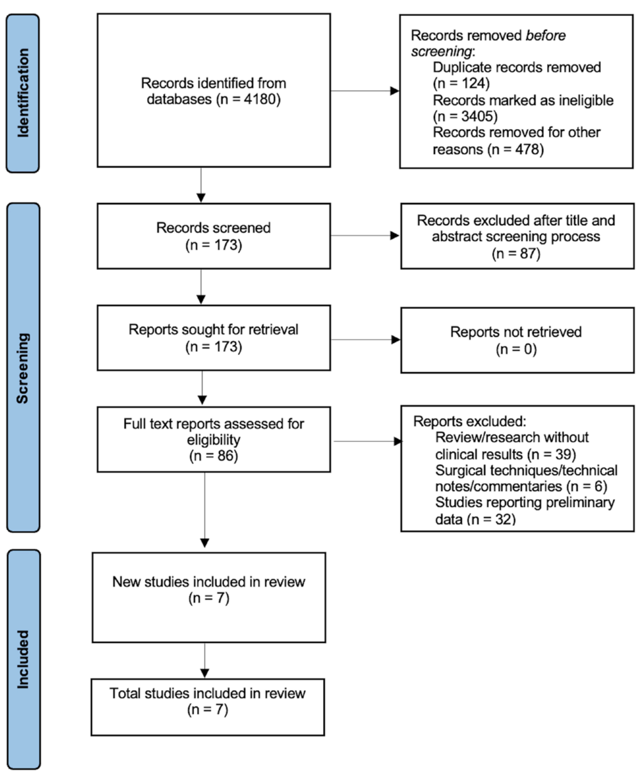

Figure 1
Prisma flow diagram.

non-controlled studies. No randomized controlled trial (RCT) was included. Comparative studies were classified as at high risk of bias if the overall score was ≤20 and at low risk of bias when >20. Non-controlled studies were considered at high risk of bias when the overall score was ≤12 and at low risk of bias when >12. Detailed MINORS items and scores of each study are provided in electronic supplementary material (ESM).

All included papers were retrospective matched cohort studies with a level of evidence III (16, 17, 18, 19, 20, 21).

The overall quality of the included studies was low, according to the GRADE system.

There were high risks of bias in all included studies according to the MINORS criteria.

Data extraction and analysis

Stepwise analysis of study design, the aim of the study, level of evidence, journal, year of publication, country, number of procedures included in the study, the surgical indication to TKA, mean age, and follow-up was independently conducted by each reviewer. Discrepancies in data extraction were discussed and resolved by a consensus meeting between the authors.

All studies were assessed for primary and secondary outcomes.

The analysis was separately conducted for patients who had a TKA following ACL reconstruction (study group) and for patients who underwent TKA for primary OA with no ACL reconstruction (control group).

Data were extracted and recorded for a stepwise analysis. Basic information about each study including study design, level of evidence, population features, country, number of patients, mean age at surgery, and mean follow-up were extracted and summarized in Table 1.

Specific features of measured outcomes were accurately assessed and data were summarized in Table 2. Details of the incidence of complications were summarized and reported in Tables 3 and 4.

Statistical analysis

Continuous variables were reported as weighted means and weighted standard deviations. Categorical variables were reported as the number of events or percentages.

For each included study, mean differences (MDs) and 95% CI were calculated for continuous outcomes, while odds ratio (OR) and 95% CI were calculated for dichotomous outcomes.

Statistical heterogeneity among the studies was assessed using the χ^2 test and I^2. A fixed-effect model was applied when I^2 <40%, and a random-effect model when I^2 ≥40%.

A *P*-value of less than 0.05 was considered statistically significant.

All analyses were completed with Review Manager 5.4.1 software (Cochrane Collaboration, Oxford, UK) and a *P*-value funnel plot was used to analyze the existence of publication bias.

Results

Basic characteristics of included studies

The flow of study identification and inclusion are shown in Fig. 1. In summary, over 3000 individual papers were initially identified and screened. Based on our review of the title and abstract, 86 full-text papers were reviewed and 7 met the inclusion criteria.

The 7 studies (16, 17, 18, 19, 20, 21, 22) involved globally 1645 participants, 619 of whom underwent TKA in previous ACL reconstruction (study group) and 1026 TKA for primary OA (control group).

All seven papers had complete reporting of the TKA procedure and reported details of the incidence of postoperative complications. The papers had similar distributions of sex, age, and types of surgery. The included studies are described in Table 1, the TKA data are summarized in Table 2 and postoperative complications are summarized in Tables 3 and 4.

Table 1 General characteristics of the included studies.

Study	Year	Country	Patients, *n*			Mean age at surgery (years)	Sex		Study design	LOE	Mean follow-up (months)
			Total	SG	CON		M	F			
Hoxie *et al.* (16)	2008	USA	107	35	72	53 (29–78)	23	12	RMCS	III	45 (2–239)
Magnussen *et al.* (17)	2012	France	44*	22	22	58.1 ± 10.2	7	15	RMCS	III	33.6 (7.2–276)
Watters *et al.* (18)	2017	USA	144	122	122	58	67	55	RMCS	III	39.6 (24–117.6)
Lizaur-Utrilla *et al.* (19)	2018	Spain	74	37	37	69.6 ± 7.1 (41–74)	22	15	RMCS	III	73.2 (60–87.6)
Chong *et al.* (20)	2018	USA	266	64	202	54 ± 9.0 (32–72)	56	45	RMCS	III	10.4 ± 10.0 (0.9–55.2)
James *et al.* (22)	2019	USA	446†	223†	223	57.2 (31–88)	144	79	RMCS	III	16.7 (2–84)
Anil *et al.* (21)	2020	USA	464‡	116‡	348‡	55.5 ± 10.1	80	36	RMCS	III	19.7 ± 7.6 (minimum 6)

*Final cohort of patients assessed for clinical evaluation at final follow-up (*n* = 16); †Study group have mixed cohort of TKA performed in previous multi-ligament reconstruction (*n* = 35) and isolated ACL reconstruction (*n* = 188); ‡Complications were assessed only on patients with a minimum of 6 months follow-up: 251 patients in the non-anterior cruciate ligament reconstruction (ACLR) group and 82 patients in the ACLR group.
CON, control; F, female; LOE, level of evidence; M, male; RMCS, retrospective matched cohort study; SG, study group.

Table 2 General features of patients in included studies.

Study	BMI	Type of graft: Graft	Type of graft: *n*	Technique	Prosthesis	Outcomes reported
Hoxie *et al.* (16)	NR	BPTB autograft	7	34 all components cemented; 1 component uncemented; 1 cemented femoral component; uncemented tibial component; patella resurfaced in all cases	24 cruciate sacrificing (posterior stabilized); 9 cruciate retaining; 3 constrained condylar designs; no stems or augments used	KSS Pre- and postoperative, ROM, technical difficulty during TKA, use of prosthetic augments or stems, PJI rate, revision surgery rate. Knee FS
		Hamstring autograft	9			
		Unknown	15			
Magnussen *et al.* (17)	26 ± 4	BPTB autograft	1	Medial parapatellar approach; patella resurfaced in all cases	Posterior-stabilized tricompartmental TKA (Tornier); polyethylene insert thickness augmentation in 3 patients with ACLR and in 2 controls; tibial stem 30 mm longer than standard in 2 patients with ACLR and in 0 control	Pre- and post operative KSS, ROM, tourniquet time, technical difficulty, use of prosthetic augments or stems, postoperative stiffness, PJI rate, revision surgery rate. IKS knee score. Blackburne-Peel Index
	28 ± 4	BPTB autograft and ITB	3			
		ITB	2			
		Synthetic ligament	3			
		NR	13			
Watters *et al.* (18)	NR	NR		Patella resurfaced in all cases	Posterior-stabilized implant design	KSS Pre- and post operative, ROM, intraoperative blood loss, operative time, PJI rate, reoperation rate
Lizaur-Utrilla *et al.* (19)	29.5 ± 5.6; 31.2 ± 6.8	BPTB graft	21	NR	Cruciate-retaining or posterior-stabilized prosthesis designs	KSS Pre- and post operative, WOMAC (pain and function), SF-12 (physical and mental), ROM, technical difficulty during TKA, use of prosthetic augments or stems, operative time, PJI rate, reoperation rate, aseptic loosening, VAS patient satisfaction
		Semitendinosus autograft	10			
		Synthetic ligament	5			
Chong *et al.* (20)	32.6 ± 6.5; 32.5 ± 6.0	NR		Medial parapatellar approach; patella resurfaced in all cases	Posterior-stabilized; Trekking modular system (Samo, Biomedica); polyethylene insert thickness augmentation in 15 patients with ACLR and in 2 controls; tibial stem in 5 patients with ACLR and in 0 control	Operative time, intraoperative blood loss, rate of VTE and nerve injury, PJI rate, reoperation rate
James *et al.* (22)	29.7	NR		NR	Use of constrained implants in 76 patients with ACLR. Use of constrained in 40 controls	DVT/PE, infection, transfusion, ROM, revision. KOOS score. Use of constrained implants. Operative time and tourniquet time
Anil *et al.* (21)	31.1 ± 5.85; 31.45 ± 6.01	NR		NR	NR	Surgical time, incidence of wound complications, length of stay, discharge disposition, 30-day readmission rate, and reoperation rate

IKS, International Knee Society Score; KOOS, Knee Injury and Osteoarthritis Outcome core; KSS, knee society score; PJI, periprosthetic joint infection; ROM, range of motion; VAS, visual analogue scale; VTE, venous thromboembolism.

Table 3 Details of the absolute number of complications reported within the studies.

	(16)		(17)		(18)		(19)		(20)		(21)		(22)	
	ACL	CON	ACL	CON	ACL	CON	ACL	CON	ACL	CON	ACL	CON	ACL	CON
Infection	NR	NR	NR	NR	4*	0*	0	2	NR	NR	4†	7†	4‡	2
Crepitus	NR	NR	NR	NR	3	0	NR	NR	NR	NR	NR	NR	NR	NR
Re-operations	NR	NR	NR	NR	11*	2*	11	19	NR	NR	33†	18†	NR	NR
Wound complications	NR	NR	NR	NR	NR	NR	NR	NR	1	0	12	17	NR	NR
Blood cloth or nerve injury	NR	NR	NR	NR	NR	NR	1	1	NR	NR	NR	NR	NR	NR
Stiffness	NR	NR	6	0	3	1	6	12	2	0	8†	26†	NR	NR
Patellar tendon avulsion	NR	NR	NR	NR	NR	NR	NR	NR	1	0	NR	NR	NR	NR
Patella baja	4	2	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
DVT/PE	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	1‡	3
Other	NR	NR	NR	NR	1	1	NR	NR	NR	NR	NR	NR	NR	NR
Total	4	2	6	0	11	2	18	34	4	0	30	67	5‡	5

†Analysis performed on a partial population with a minimum of 6 months follow-up (82 patients in the study group and 251 patients in the control group); *statistically significant values; ‡Data obtained with the exclusion of 35 patients with previous multi-ligament injuries.
ACL, anterior cruciate ligament; CON, control group;NR, not reported.

Table 4 Sub-group analysis of the type of complications reported in the study and control group with number of participants, reported odd ratio (OR), 95% confidence interval (95%CI), and the relative *P*-value.

Outcome of subgroup	Studies reporting complications		Participants, *n*			Incidence		OR (95%CI)	*P*-Value
	n	Study	Total	SG	CON	SG	CON		
Wound complications	2	(19), (21)	538	153	385	8.5%	4.4%	2.30 (1.09, 4.86)	0.03*
Stiffness	5	(17), (18), (19), (20), (21)	961	327	634	7.6%	6.1%	1.68 (0.97, 2.90)	0.06
Infection	4	(18), (20), (21), (22)	1420	525	895	2.3%	1.3%	2.14 (0.92, 5.01)	0.08
Reoperation (excluding revisions)	3	(18), (20), (21)	843	268	575	20.5%	6.8%	4.64 (1.61, 13.31)	0.004*
DVT/PE	1	(22)	411	188	223	0.5%	1.3%	0.39 (0.04, 3.80)	0.42
Patellar crepitus	1	(18)	244	122	122	2.5%	0%	7.18 (0.37, 140.41)	0.19
Patella baja	1	(16)	107	35	72	11.4%	2.8%	4.52 (0.79, 25.97)	0.09
Blood cloth or nerve injury	1	(20)	266	64	202	1.6%	0.5%	3.19 (0.20, 51.75)	0.41
Patellar tendon avulsion	1	(19)	74	37	37	2.7%	0%	3.08 (0.12, 78.14)	0.49
Other	1	(18)	144	122	122	0.8%	0.8%	1.00 (0.06, 16.17)	1.00
Total	7	(16), (17), (18), (19), (20), (21), (22)	1479	550	929	14.2%	11.8%	2.15 (1.51, 3.06)	<0.001*

*significant values.
SG, study group.

Results of the meta-analysis

Comparison of incidence of complications between the two groups

All seven studies included in this systematic review and meta-analysis (16, 17, 18, 19, 20, 21, 22) reported the incidence of postoperative complications. These studies reported data on 1645 participants. However, complications data were available only for 1479 patients, 550 in the study group and 929 in the control group.

Statistical heterogeneity was χ^2 = 7.64; I^2 = 21%; P = 0.27, and a fixed-effect model was used for analysis.

In five studies (16, 19, 20, 21, 22), there was no statistical difference in complication rate between the two groups, but the overall meta-analysis showed that TKA in previous ACL reconstruction had a significantly higher complication rate when compared to the control group who underwent TKA for primary OA (OR = 2.15; 95% CI = 1.51–3.06; $P < 0.001$) (Fig. 2). The overall complication rate of the study group was 14.2% vs 11.8% of the control group.

The details of reported complications are summarized in Tables 3 and 4.

Comparison of operative time between the two groups

Among the seven cited investigations, only four studies (17, 20, 21, 22) reported quantitative data on operative times.

These studies involved 1257 patients including 462 in the previous ACL reconstruction group and 795 in the control group.

Statistical heterogeneity was $\chi^2 = 2.10$; $I^2 = 0\%$; $P = 0.55$, and a fixed-effect model was used for the analysis.

Although two studies (17, 21) reported no significant increase in operative time, the meta-analysis showed a significant difference in operative times between TKA in previous ACL reconstruction and TKA in the primary OA group (MD = 11.19 min; 95% CI = 7.92–14.45; $P < 0.001$) (Fig. 3).

The calculated weighted mean and standard deviation of operative times were 95.2 ± 9.2 min for the study group vs 84.0 ± 9.6 min for the control group.

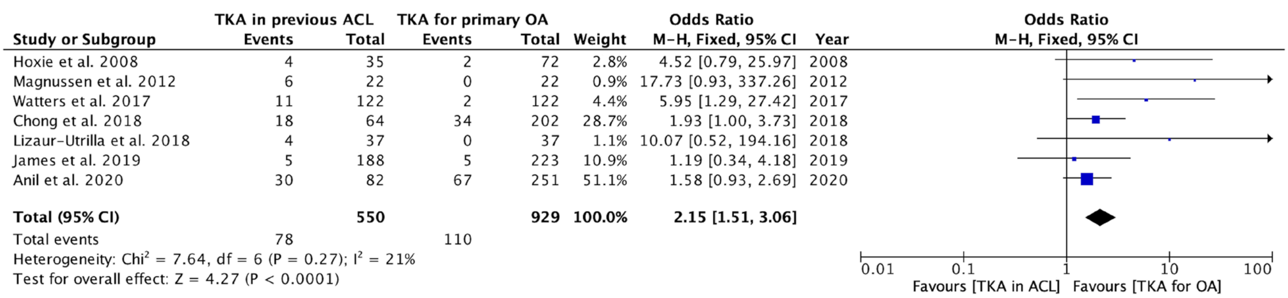

Figure 2
Comparison of the incidence of complications between TKA in a previous ACL reconstruction and TKA for primary OA. ACL, anterior cruciate ligament; OA, osteoarthritis; TKA, total knee arthroplasty.

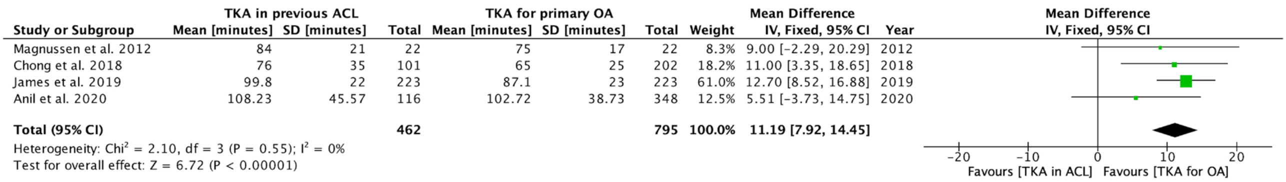

Figure 3

Comparison of the operative times between TKA in a previous ACL reconstruction and TKA for primary OA. ACL, anterior cruciate ligament; OA, osteoarthritis; TKA, total knee arthroplasty.

Comparison of the use of revision components (stems or constrained implants) between the two groups

Among the seven selected studies, three papers (17, 19, 22) reported detailed data on the type of components used for TKA. These research articles involved 529 patients, 247 in the study group and 282 in the control group.

Statistical heterogeneity was χ^2 = 2.45; I^2 = 18%; P=0.29, and a fixed-effect model was used for analysis.

All the analyzed studies reported a significant increase in the use of revision components (tibial stems or constrained implants) in patients who had previous ACL reconstruction.

Excluding patients with previous multi-ligament injuries (n = 35), the meta-analysis showed a significant difference in the use of revision components in the study group vs the control group (OR=2.16; 95% CI=1.39–3.38; P < 0.001) (Fig. 4).

Precisely, 2 studies (17, 19) involving overall 118 patients (59 for each group) reported increased use of tibial stems, 13.6% in the study group vs 0% in the control group (OR=10.39; 95% CI=1.27—84.90; P=0.03).

James *et al.* (22) provided detailed implant data of a mixed cohort of 446 patients who underwent TKA in a previous ACL reconstruction (n = 188), in a previous multi-ligament reconstruction (n = 35), and for primary OA (n = 223). With the exclusion from this meta-analysis of a sub-group of patients with previous multi-ligament reconstructions (n = 35), there was a significantly increased use of constrained implants, in patients with a previous ACL reconstruction (29.3% of cases) vs17.9% in TKA for primary OA (OR=1.89; 95% CI=1.19–3.01; P=0.007).

Two studies (17, 19) reported details of intraoperative releases performed during surgery to obtain soft tissue balancing in TKA and meta-analysis showed a significant increase of soft tissue releases in previous ACL reconstructions (67.8% vs 15.3%; P < 0.001) (Table 5).

Finally, Lizaur-Utrilla *et al.* (19) reported the requirement of increased polyethylene thickness in 40.5% of patients in the study group vs 5.5% of patients in the control group (OR=11.93; 95% CI=2.49–57.28; P = 0.002).

Details of the sub-group analysis are summarized in Table 5.

Comparison of infections between the two groups

Among the seven selected studies, four papers (18, 20, 21, 22) reported the incidence of infection following TKA. These research articles involved 1420 patients, 525 in the study group and 895 in the control group.

All the analyzed studies reported no significant differences in infection rates between the two groups.

The meta-analysis confirmed no significant difference between the two groups regarding the incidence of infections (OR=2.14; 95% CI=0.92–5.01, P = 0.08) (Fig. 5).

The mean infection rate of the study group was 2.3% vs 1.2% of the control group.

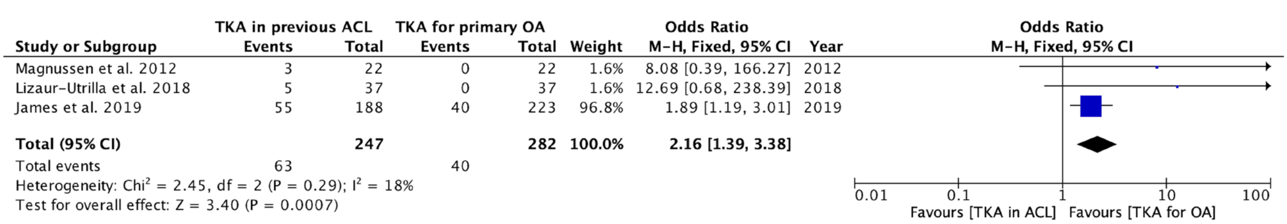

Figure 4

Comparison of the incidence for requirement of revision components between TKA in a previous ACL reconstruction and TKA for primary OA. ACL, anterior cruciate ligament; OA, osteoarthritis; TKA, total knee arthroplasty.

Table 5 Sub-group analysis of the type of prosthetic components and intraoperative additional procedures for difficult exposure in the study group and control group with participants, reported odd ratio (OR), 95% confidence interval (95% CI), and the relative *P*-value.

Outcome of subgroup	Studies reporting outcomes		Participants, *n*			Incidence		OR (95%CI)	*P*-Value
	n	Study	Total	SG	CON	SG	CON		
Revision components	3	(17), (19), (22)	529	247	282	25.5%	14.2%	2.16 (1.39, 3.38)	<0.001*
Constrained implant	1	(22)	411	188	223	29.3%	17.9%	1.89 (1.19, 3.01)	0.007*
Tibial stem	2	(17), (19)	118	59	59	13.6%	0.0%	10.39 (1.27, 84.90)	0.03*
Increased polyethylene thickness	1	(19)	74	37	37	40.5%	5.4%	11.93 (2.49, 57.28)	0.02*
Soft tissue release	2	(17), (19)	118	59	59	67.8%	15.3%	11.24 (4.38, 28.86)	<0.001*
Tibial tubercle osteotomy	1	(17)	44	22	22	13.6%	0.0%	8.08 (0.39, 166.27)	0.18
Quad snip	1	(19)	74	37	37	2.7%	0.0%	3.08 (0.12, 78.14)	0.49

*significant values.
CON, control; SG, study group.

Comparison of revision rate between the two groups

Among the seven selected studies, five papers (16, 18, 20, 21, 22) reported the incidence of revision surgery following TKA. These research articles involved 1564 patients, 597 in the study group and 967 in the control group.

All the analyzed studies reported no significant differences in revision rates between the two groups.

The meta-analysis confirmed no significant difference between the two groups in the incidence of revision surgery (OR = 1.20; 95% CI = 0.80–1.79, $P = 0.38$) (Fig. 6).

The mean revision rate of the study group was 7.2% vs 8.3% of the control group.

Comparison of ROM between the two groups

Among the seven selected studies, four papers (16, 18, 19, 22) reported detailed quantitative data of ROM following TKA and two by them (16, 18) did not report S.D. Only 2 studies (19, 22) were finally included in the meta-analysis involving 520 participants, 260 for the study group and 260 for the control group.

Details of analyzed data are summarized in Table 6.

Preoperative extension

There was no difference among preoperative extension deficit values of the study group (4.1 ± 4.4 degrees) and the control group (4.3 ± 2.8 degrees) (MD = −0.09; 95% CI = −2.95 to 3.13; $P = 0.95$).

Postoperative extension

Meta-analysis showed a significant difference between postoperative values of extension among patients of the study group (1.5 ± 2.2 degrees) and the control group (2.0 ± 1.9 degrees) (MD = −0.56; 95% CI= −1.07 to −0.05; $P = 0.03$).

Preoperative flexion

Meta-analysis showed a significant difference between the preoperative flexion values of the study group (116.2 ± 20.5 degrees) and the control group (116.3 ± 14.8 degrees) (MD = −4.83; 95% CI = −7.45 to −2.22; $P < 0.001$).

Postoperative flexion

There was no significant difference between postoperative values of flexion among patients of the study group (116.3 ± 9.8 degrees) and the control group (117.3 ± 9.1 degrees) (MD = −0.96; 95% CI = −0.98 to 2.89; $P = 0.33$).

Comparison of clinical outcomes between the two groups

Among the seven selected studies, five papers (16, 17, 18, 19, 22) reported clinical quantitative data of functional scores following TKA. In three studies (16, 18, 19) there were quantitative comparative data of the postoperative KSS score without a significant difference among study and control groups. However, two studies (16, 18) did not

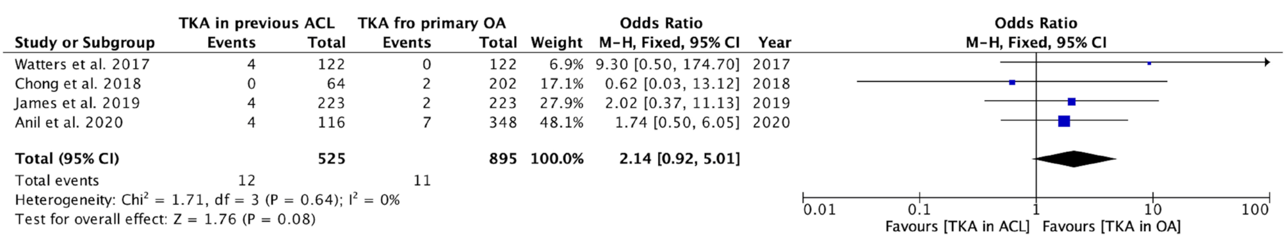

Figure 5
Comparison of the incidence of infections between TKA in a previous ACL reconstruction and TKA for primary OA. ACL, anterior cruciate ligament; OA, osteoarthritis; TKA, total knee arthroplasty.

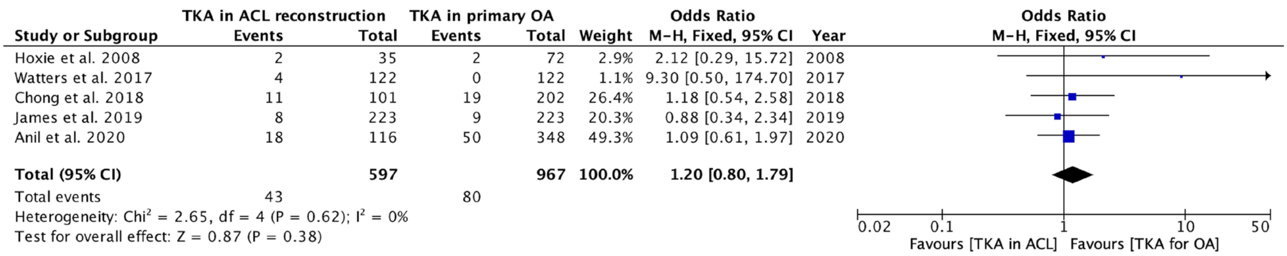

Figure 6
Comparison of the incidence of revision surgery between TKA in a previous ACL reconstruction and TKA for primary OA. ACL, anterior cruciate ligament; OA, osteoarthritis; TKA, total knee arthroplasty.

report standard deviation not allowing the meta-analysis of KSS values.

James *et al.* (22) reported Knee Injury and Osteoarthritis Outcome Score (KOOS) for joint replacement in the study and control group without detecting significant differences.

Magnussen *et al.* (17) reported the International Knee Society Score (IKS) values without detecting differences among study and control groups. Considering the high heterogeneity of assessed clinical scores, the meta-analysis was not possible.

Publication bias

A funnel plot was performed with the incidence of complications as the indicator. A total of seven studies (16, 17, 18, 19, 20, 21, 22) were included in the analysis. The observed log odds ratios ranged from 0.4413 to 3.4553, with the majority of estimates being positive (100%). According to the Q-test, there was no significant amount of heterogeneity in the true outcomes ($P = 0.2838$; $I^2 = 0\%$). A 95% prediction interval for the true outcomes is given between 0.35 and 1.10. One study (21) had a relatively large weight compared to the rest of the studies. The seven points in the funnel plot suggest a lower impact of publication bias on the results (Fig. 7). The regression test indicated funnel plot asymmetry ($P = 0.019$) but not the rank correlation test ($P > 0.05$). According to Cook's distances, none of the studies could be considered to be overly influential.

Discussion

The main finding of this meta-analysis is that a TKA in a previous ACL reconstruction has a significantly higher complication rate, longer operative times, and a higher need for revision components and intraoperative soft tissue releases in comparison to TKA for primary OA with no previous ACL reconstruction.

However, there was no significant difference in revision surgery rate and infection rate between groups even if with a tendency toward an increase of the latter.

As the rate of ACL injuries in sport participation is progressively growing (23), the orthopedic surgeon can expect to manage an increasing number of TKA in patients with a history of ACL reconstruction (7, 24, 25). To date, this is the first systematic review and meta-analysis that summarizes the clinical outcomes of TKA following ACL reconstruction comparing the results with a population of patients affected by primary OA with no previous ACL reconstruction.

ACL injury and knee laxity are known to cause degenerative joint changes that can result in a varus

Table 6 Comparative preoperative and final data of the range of motion expressed as means ± s.d. and range of values (in brackets) of extension deficit and flexion.

Study	Extension deficit				Flexion			
	Preoperative		Postoperative		Preoperative		Postoperative	
	ACL	Control	Previous ACL	Control	ACL	Control	ACL	Control
Hoxie *et al.* (16)	6 (0–15)	5 (0–15)	0.4 (−10 to 6)	0.6 (−6 to 5)	101 (15–135)	105 (55–135)	105 (60–130)	104 (50–130)
Magnussen *et al.* (17)	2.3 ± 4.5*	−0.5 ± 3.7*	−1.1 ± 3.5	−2.5 ± 2.6	122 ± 12	118 ± 21	119 ± 13	108 ± 14
Watters *et al.* (18)	4.1	3.9	0.2	0.3	119.1*	123.2*	125.5	126.8
Lizaur-Utrilla *et al.* (19)	6.9 ± 1.7*	5.3 ± 1.5*	3.4 ± 3.6	3.6 ± 3.7	92.3 ± 11.1	96.6 ± 12.4	109.4 ± 10.7	110.2 ± 11.3
Chong *et al.* (20)	NR	NR	NR	NR	NR	NR	NR	NR
James *et al.* (22)	2.0 ± 3.9*	3.7 ± 7.5*	0.4 ± 1.5	0.9 ± 3.8	109.0 ± 14.6*	111.6 ± 15.2*	119.9 ± 10.2	118.2 ± 11.5
Anil *et al.* (21)	NR	NR	NR	NR	NR	NR	NR	NR

*Statistically significant difference between groups.

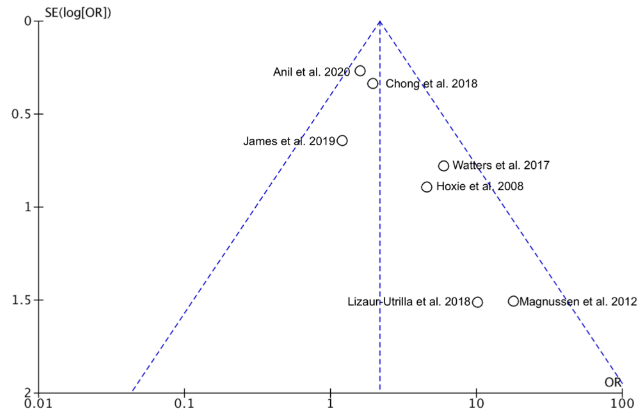

Figure 7

Analysis of publication bias of postoperative complications from seven studies (funnel plot of the standard error of log odds ratio vs odds ratio for the incidence of postoperative complications in TKA in the previous ACL group compared with TKA for the primary OA group). ACL, anterior cruciate ligament; OA, osteoarthritis; TKA, total knee arthroplasty.

deformity and articular defects in the posteromedial tibial plateau due to abnormal kinematics and cartilage wear (26, 27). These joint deformities represent a specific pattern that significantly differs from those of primary knee OA (28). In the case of ACL reconstruction, the presence of bone tunnels, graft fixation devices, and surgical scars of the harvest site can reduce the bone stock and compromise the knee stability, leading to difficult articular exposure and increased requests for tibial stems or constrained implants to achieve a proper balancing of the knee arthroplasty (17, 19, 22).

Accordingly, the present meta-analysis revealed that patients with a previous ACL reconstruction have an increased need for revision components (stems and constrained implants), higher requests for increased liner thickness, higher wound complications (P = 0.03), and higher reoperation excluding revision rate (P = 0.004) (Table 4).

Although the reviewed studies (16, 17, 18, 19, 22) reported no differences between groups in postoperative ROM values, the present meta-analysis demonstrated that patients with a previous ACL reconstruction had better postoperative extension (P = 0.03) compared to the control group. The present finding may be explained as the consequence of the soft tissue release, performed on the study group. However, the detected mean difference may be clinically not relevant (MD = −0.56 degrees).

Several grafts and fixation devices are nowadays available (29) with different donor site morbidity and various potential impacts on the extensor mechanism and bony structures of the knee (30). Only three papers (16, 17, 19) reported details on the graft type used for ACL reconstruction and no one reported the specific fixation device and related detailed outcomes not allowing a subgroup analysis. Due to this limitation, the influence of a specific graft type and extra-articular reconstruction on complications and outcomes of a TKA were not possible to analyze. Further studies are necessary to investigate if the graft choice and surgical technique in ACL reconstruction may influence the clinical outcome of a TKA.

Different authors (10, 18, 19, 20) reported serious concerns encountered during TKA with preexisting fixation devices from prior ACL reconstruction, that required hardware removal in 45–84% of cases, with significantly increased operative times. The difficulties were mainly due to the implants that prevent the safe passage of intra-medullary instruments or placement of the prosthetic component itself.

All the included studies reported no significant differences in clinical and functional scores at the final follow-up assessment, concluding that ACL reconstruction does not affect the clinical results. However, there was high heterogeneity of clinical scores used to assess the measured outcomes impeding the meta-analysis of quantitative data and strong conclusions.

This research has several limitations: first of all, a limited number of articles met the selection criteria and several studies had a very small sample size and reported high heterogeneity of functional scores. Moreover, the quality of the included studies was low with a high risk of bias and for this reason, a type II error cannot be excluded. One more limitation is that extensive preoperative information about knee deformity, severity of arthritis, ACL status, and joint stability at the time of TKA procedure is lacking. Finally, studies reported limited data on the TKA technique and design and these factors may influence operative times and clinical outcomes.

Given the retrospective nature of the included studies, further prospective researches with large sample size and detailed data on graft type, drilling technique, and ACL fixation devices are necessary to provide a higher level of evidence.

On the other hand, this is the first meta-analysis with a precise design and low heterogeneity of data that allowed to collect results of 1645 TKA, 619 of whom underwent TKA in previous ACL reconstruction and 1026 TKA for primary OA without previous ACL reconstruction.

Conclusion

This systematic review of the literature and meta-analysis suggests that TKA in a previous ACL reconstruction has a significantly higher complication rate, longer operative times, and a higher need for revision components and intraoperative soft tissue releases in comparison to TKA for primary OA without previous ACL reconstruction.

Careful preoperative planning which includes the availability of revision implants and appropriate patient counseling regarding TKA risk of complications and results is recommended.

ICMJE Conflict of interest Statement

L Zagra declares that he is affiliated to AAHKS affiliation; he has received payment for presentations from LimaCorporate, ZimmerBiomet, Stryker, Mathys, BD and Angelini; is a paid consultant for Medacta, DePuy, Stryker, 3M; and has received research support from LimaCorporate, Medacta, and DePuy. Other authors declare that they have no affiliations with or involvement in any organization or entity with any financial interest or non-financial interest in the subject matter or materials discussed in this manuscript.

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