The impact of concomitant meniscal surgery on the clinical outcomes of anterior cruciate ligament reconstruction

results from the UK National Ligament Registry

From University College London Hospitals NHS Trust, London, UK

Correspondence should be sent to A. Gabr aymangabr@hotmail.co.uk

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A. Gabr,[1,2] A. Fontalis,[2] J. Robinson,[3] W. Hage,[4] S. O'Leary,[5] T. Spalding,[6] F. S. Haddad[2]

[1]West Suffolk Hospital NHS Trust, Bury St Edmunds, UK
[2]University College London Hospitals NHS Trust, London, UK
[3]North Bristol NHS Trust, Bristol, UK
[4]North Cumbria NHS Trust, Cumbria, UK
[5]The Royal Berkshire Hospital NHS Trust, Reading, UK
[6]Cleveland Clinic London, London, UK

Aims

The aim of this study was to compare patient-reported outcomes (PROMs) following isolated anterior cruciate ligament reconstruction (ACLR), with those following ACLR and concomitant meniscal resection or repair.

Methods

We reviewed prospectively collected data from the UK National Ligament Registry for patients who underwent primary ACLR between January 2013 and December 2022. Patients were categorized into five groups: isolated ACLR, ACLR with medial meniscus (MM) repair, ACLR with MM resection, ACLR with lateral meniscus (LM) repair, and ACLR with LM resection. Linear regression analysis, with isolated ACLR as the reference, was performed after adjusting for confounders.

Results

From 14,895 ACLR patients, 4,400 had two- or five-year Knee injury and Osteoarthritis Outcome Scores (KOOS) available. At two years postoperatively, the MM repair group demonstrated inferior scores in KOOS pain ($\beta = -3.63$, $p < 0.001$), symptoms ($\beta = -4.88$, $p < 0.001$), ADL ($\beta = -2.43$, $p = 0.002$), sport and recreation ($\beta = -5.23$, $p < 0.001$), quality of life (QoL) ($\beta = -5.73$, $p < 0.001$), and International Knee Documentation Committee ($\beta = -4.1$, $p < 0.001$) compared with the isolated ACLR group. The LM repair group was associated with worse KOOS sports and recreation scores at two years ($\beta = -4.264$, $p < 0.001$). At five years, PROMs were comparable between the groups. At five years, PROMs were comparable between the groups. Participants undergoing ACLR surgery within 12 weeks from index injury demonstrated superior PROMs at two and five years.

Conclusion

Our study showed that MM repair, and to a lesser extent LM repairs in combination with ACLR, were associated with inferior patient-reported outcome measures (PROMs) compared to isolated ACLR at two years postoperatively, while meniscal resection groups exhibited comparable outcomes. However, by five years postoperation, no significant differences in PROMs were evident. Further longer-term, cross-sectional studies are warranted to investigate the outcomes of ACLR and concomitant meniscal surgery.

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Take home message

- This study indicates that medial meniscus repair, and to a lesser extent lateral meniscal repair, combined with anterior cruciate ligament reconstruction (ACLR), were linked to lower patient-reported outcome measures (PROMs) compared to isolated ACLR at two years postoperatively, while meniscal resection groups showed similar outcomes.
- However, at five years postoperatively, PROMs differences were no longer significant.

Introduction

Anterior cruciate ligament (ACL) injury is one of the most frequently treated knee conditions with an estimated annual incidence rate of 68.6 per 100,000 population.[1] ACL injuries are commonly associated with meniscal tears.[2,3] The menisci have a vital role in load transmission, joint lubrication, proprioception, and knee stability.[4-6] Surgical management of meniscal tears has evolved from total and partial meniscectomy to meniscal repair with emphasis on meniscal preservation. There is well documented evidence in the literature that meniscal resection leads to increased contact stresses and accelerated degenerative changes in the knee.[7-9] Consequently, there has been a growing trend towards meniscal preservation surgery.[10] Multiple studies have reported higher success rates for meniscal repair when associated with ACL reconstruction (ACLR) compared to isolated meniscal repair.[11,12] This could potentially be attributed to the stability provided by the ACLR, and the favourable healing environment fostered by the haemarthrosis and release of bone marrow elements during femoral and tibial tunnel drilling.[13-15]

Several studies have reported lower subjective outcome measures and higher incidence of osteoarthritis at long-term follow-up for patients who have undergone meniscal resection with concomitant ACLR compared to patients with isolated ACLR.[16-19] However, there is conflicting evidence concerning the short- and medium-term impact of meniscal resection or repair with concomitant ACLR on clinical outcomes. In a prospective study involving 313 athletes, Byrne et al[20] reported no difference in subjective or objective outcomes between patients who had meniscal repair or resection with concomitant ACLR compared to patients with isolated ACLR at ten months postoperatively. Conversely, Phillips et al[21] studied 15,392 patients from the Swedish Ligament Registry and reported worse outcomes for patients who underwent meniscal resection alongside ACLR compared to those with isolated ACLR or concomitant meniscal repair at two years' follow-up.

Previous studies have examined the unique biomechanical contributions of the medial and lateral menisci in the ACL-deficient knee.[22] The medial meniscus (MM), particularly its posterior horn, has critical secondary stabilizer function in resisting anterior tibial translation, while the lateral meniscus (LM) is a significant dynamic restraint against rotation and translation under a coupled valgus stress and internal rotation.[22] However, existing literature remains unclear regarding potential differences in clinical outcomes between MM and LM surgeries when associated with ACLR. Thus, the primary objective of this study was to compare patient-reported outcome measures (PROMs) following meniscal resection or repair for MM and LM injuries with concomitant ACLR, versus isolated ACLR. Our hypothesis was that patients undergoing meniscal interventions alongside ACLR would manifest inferior preoperative PROM scores and two-year postoperative PROM scores, but comparable five-year postoperative PROM scores when compared to patients undergoing isolated ACLR. Additionally, we hypothesized there would be no difference in outcomes between medial and lateral meniscal surgeries.

Methods

This retrospective cohort study encompassed all patients in the UK National Ligament Registry (NLR) undergoing primary ACL reconstruction over a ten-year period between 1 January 2013 and 31 December 2022. All patients included in this study had signed informed consent before their ACLR surgery, allowing for their data to be collected and stored on the UK NLR database for both clinical and research purposes. This study did not require ethical committee approval as it only involved retrospective data analysis from data collected on the NLR. Data are entered by both surgeons and patients on the NLR through a web-based platform. Data capturing is performed via this platform and commences with the surgeon generating a patient's encounter before registering the patient's demographics, surgical details, and complications. Once informed consent is obtained, patients are invited to record details related to the injury and complete PROM questionnaires. The PROMs and quality of life (QoL) metrics captured in the NLR include the Knee injury and Osteoarthritis Outcome Score (KOOS),[23] subjective International Knee Documentation Committee (IKDC) score,[24] EuroQol five-dimension (EQ-5D) index, and EQ-5D visual analogue scale (VAS).[25] Invitations are sent to the patients to complete the PROMs questionnaires at specified intervals: preoperatively, six months, one year, two years, five years, and ten years.

Study population and outcomes

Research participants were selected for analysis in this study if all of the following were satisfied: 1) they underwent primary ACL reconstruction with the use of autograft; 2) the index procedure was performed between 1 January 2013 and 31 December 2022; 3) no associated fracture or neurovascular injuries present; 4) they had either ACL reconstruction alone or combined with medial or lateral meniscal repair or reconstruction; and 5) KOOS scores were available at two or five years following the index procedure.

Patients were excluded from the study if they 1) underwent ACL repair; 2) had any of the following associated surgical procedures in addition to primary ACL reconstruction: lateral tenodesis, anterolateral ligament surgery, collateral ligament surgery, high tibial osteotomy, posterior cruciate ligament (PCL) surgery, or posterolateral corner surgery; 3) if allograft or synthetic graft was used; 4) if no KOOS scores were available at two or five years; or 6) if they underwent both medial and lateral meniscal surgery in the injured knee.

We extracted the following demographic data and patients characteristics: age, sex, BMI, smoking status, time from injury to surgery, type of autograft used, and presence of concomitant chondral injury. The following PROMs were also extracted: KOOS, EQ-5D Index, EQ-5D VAS, and and IKDC score. Patients were categorized into five groups based on the presence of any associated surgery: ACL reconstruction alone, ACL reconstruction and medial meniscus repair, ACL

Table I. Comparison of baseline and patient characteristics between patients on the registry among the groups.

Variable	Isolated ACLR (n = 2,423)	ACLR + MM repair (n = 604)	ACLR + MM resection (n = 625)	ACLR + LM repair (n = 334)	ACLR + LM resection (n = 414)
Sex, n (%)					
Female	1,032 (42.6)	223 (36.9)	208 (33.3)	115 (34.4)	95 (22.9)
Male	1,391 (57.4)	381 (63.1)	417 (66.7)	219 (65.6)	319 (77.1)
Median age, yrs (IQR)	29.4 (23.1 to 38.8)	28.3 (22.2 to 37.1)	36.7 (27.7 to 45.7)	26.1 (20.1 to 34)	28.6 (23 to 36.1)
Median BMI, kg/m² (IQR)	25.1 (22.9 to 27.9)	25.1 (26.5 to 29.6)	26.5 (24.1 to 29.6)	24.7 (22.9 to 27)	25.85 (23.5 to 28.9)
Median time from injury to surgery, mths (IQR)	4.9 (2.7 to 8.8)	4.3 (1.9 to 8.3)	6.2 (3.7 to 12.4)	4.1 (2.1 to 8.5)	5.5 (3 to 10.2)
Time from injury to surgery < 12 wks, n (%)	394 (28.7)	99 (35.2)	40 (17.9)	87 (41.2)	51 (7.6)
Autograft type, n (%)					
Hamstring	2,223 (91.9)	551 (91.5)	582 (93.1)	300 (90.1)	373 (90.1)
Patella tendon	186 (7.7)	49 (8.1)	43 (6.9)	28 (8.4)	40 (9.7)
Quadriceps	9 (0.4)	2 (0.3)	0 (0)	5 (1.5)	1 (0.2)
Smoking status, n (%)					
Non-smoker	1,707 (77.3)	427 (76.8)	374 (66.8)	265 (83.3)	288 (76.8)
Smoker	190 (8.6)	53 (9.5)	49 (8.8)	16 (5)	41 (10.9)
Ex-smoker	310 (14)	76 (13.7)	137 (24.5)	37 (11.6)	46 (12.3)
Concomitant cartilage pathology, n (%)	510 (21.1)	177 (29.3)	255 (40.8)	69 (20.7)	123 (29.7)

ACLR, anterior cruciate ligament reconstruction; LM, lateral meniscus; MM, medial meniscus.

Table II. Depicting the types of medial and lateral meniscus tears within the study's population.

Variable	Medial meniscus tears, n (%)	Lateral meniscus tears, n (%)
Bucket handle tear	433 (36.7)	129 (16.8)
Complex tear	175 (14.8)	114 (14.8)
Posterior horn	198 (16.7)	165 (21.4)
Vertical	138 (11.7)	65 (8.5)
Other	104 (8.8)	86 (11.2)
Radial	47 (3.9)	102 (13.2)
Parrot beak (flap)	44 (3.7)	65 (8.5)
Degenerate horizontal	27 (2.3)	23 (3)
Cleavage tear	17 (1.4)	20 (2.6)

reconstruction and medial meniscus resection, ACL reconstruction and lateral meniscus repair, and ACL reconstruction and lateral meniscus resection. The primary objective of this study was to report PROMs at different timepoints and assess whether any differences were evident at two or five years among the groups.

Statistical analysis

The absolute number and percentage were used for categorical data and the Pearson chi-squared test or Fisher's exact test were used for comparisons. PROM scores are presented using the median (IQR). To evaluate whether any differences were evident in PROM scores at baseline and two and five years among the groups, linear regression was used, with isolated ACLR as the reference group, after adjusting for age, sex, presence of chondral injury, and time from injury to surgery (< 12 or > 12 weeks). Subgroup analyses were performed to evaluate whether time to surgery was associated with differences in postoperative PROM scores. The independent samples Mann-Whitney U test was used for subgroup comparisons regarding time to surgery, while the Kruskal-Wallis one-way analysis of variance (ANOVA) was used for differences among the different autograft types. Pairwise comparisons were performed after adjusting with the Bonferroni correction. All analyses were performed using the IBM SPSS statistics software for Mac v. 29 (IBM, USA). The statistical significance threshold was set at $p < 0.05$; two-tailed.

Results

Study population

Interrogation of the UK NLR yielded 17,491 participants registered on the database between 1 January 2013 and 31 December 2022. After excluding patients with an associated

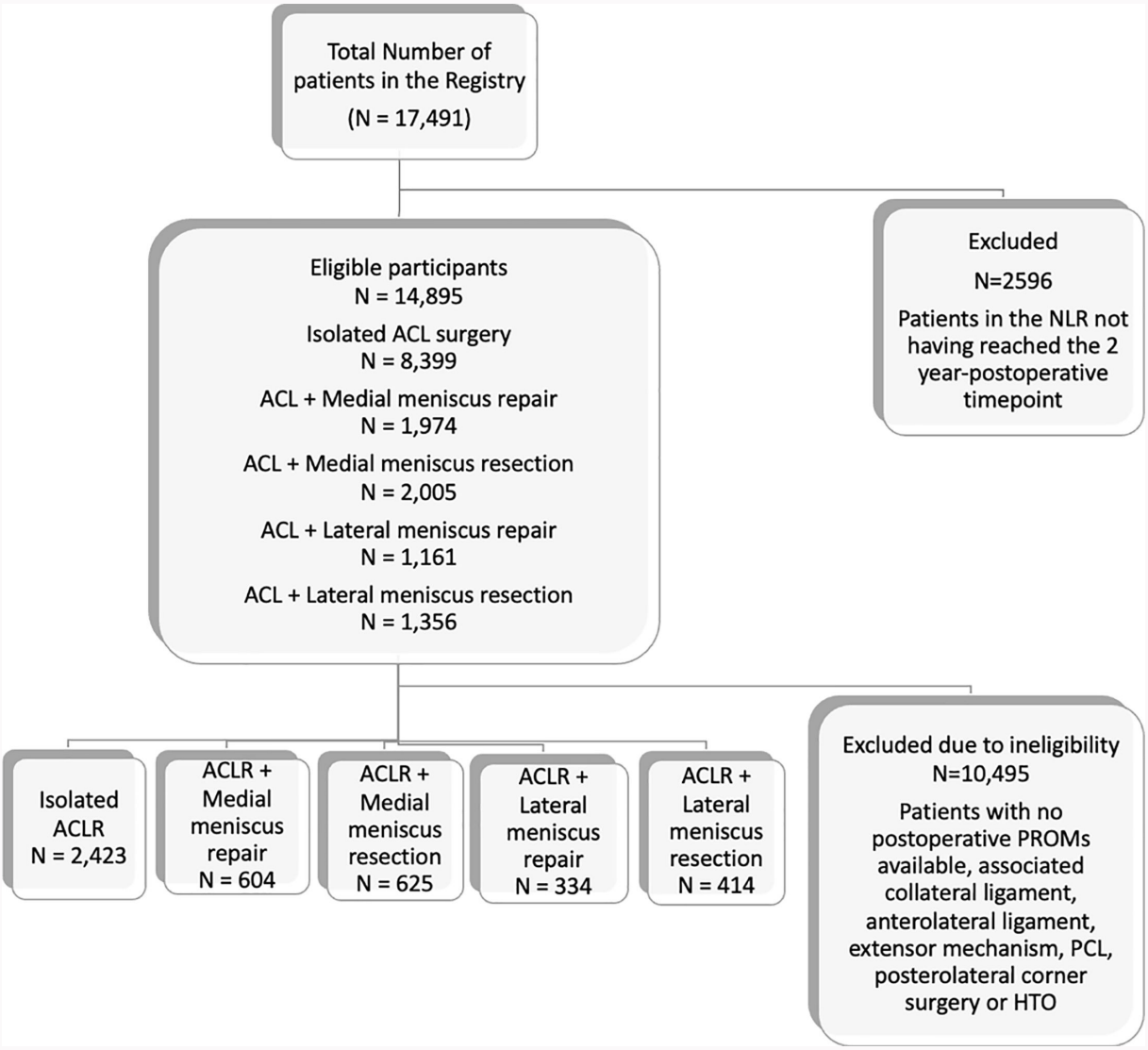

Fig. 1
Schematic representation delineating the flow of the participants throughout the study. ACLR, anterior cruciate ligament reconstruction; HTO, heterotopic ossification; NLR, National Ligament Registry; PCL, posterior cruciate ligament; PROM, patient-reported outcome measure.

procedure defined in the exclusion criteria, 14,895 patients were eligible. Out of those, 4,400 patients had KOOS scores either at two or five years and were included in the final analysis (Figure 1). We compared 2,423 participants who had undergone isolated ACLR, with 604 patients who had ACLR and MM repair, 625 who had ACLR and MM resection, 334 who had ACLR and LM repair, and 414 who had ACLR and LM resection.

Approximately two-thirds of the study population were male. The age of the study cohort ranged from 26.1 to 36.7 years. Baseline and patients' characteristics are presented in Table I. Bucket handle tears were the most common type of MM tear (37%) (Table II).

Baseline patient-reported outcome measures

Table III presents the baseline PROM scores among the groups, whereas the linear regression models after adjusting for age, sex, chondral pathology, and time to surgery (less or more than 12 weeks) can be found in Table IV. Compared with the isolated ACL reconstruction group, the medial repair and resection groups had significantly worse preoperative KOOS and IKDC scores. In detail, the medial meniscal repair group had significantly worse KOOS symptoms, QoL, and IKDC scores, while the medial meniscal resection group had worse baseline scores across all KOOS subscales except sport and recreation function and IKDC. The lateral meniscus repair and resection groups had inferior baseline scores compared with the isolated ACL group; however, this did not reach statistical significance.

PROMs comparison at follow-up

Tables V and VI present the PROM scores across the different timepoints captured in the NLR. Comparisons of KOOS subscales, IKDC, and EQ-5D scores at two years postoperatively showed statistically significant differences between the ACL reconstruction group and the medial meniscal repair group (Table VII): KOOS pain (β = -3.63, $p < 0.001$), KOOS symptoms (β = -4.88, $p < 0.001$), KOOS ADL (β = -2.43, $p = 0.002$), KOOS sports and recreation (β = -5.23, $p < 0.001$), and KOOS QoL (β = -5.73, $p < 0.001$), IKDC (β = -4.1, p

Table III. Baseline Knee injury and Osteoarthritis Outcome Scores, EuroQol five-dimension index scores, and International Knee Documentation Committee scores among the groups. All data are presented as medians (IQRs).

PROM	Isolated ACLR (n = 2,423)	ACL + MM repair (n = 604)	ACL + MM resection (n = 625)	ACL + LM repair (n = 334)	ACL + LM resection (n = 414)
KOOS pain	72 (58 to 83)	67 (53 to 81)	67 (50 to 81)	70.5 (56.5 to 83)	69 (56 to 83)
KOOS symptoms	64 (50 to 79)	61 (46 to 75)	61 (46 to 79)	61 (50 to 75)	64 (50 to 75)
KOOS ADL	84 (68 to 94)	79 (63 to 91.5)	80 (60 to 93)	81 (66 to 94)	79 (65 to 94)
KOOS sport and recreation function	40 (20 to 60)	35 (15 to 55)	35 (15 to 60)	40 (20 to 60)	40 (20 to 60)
KOOS QoL	31 (19 to 44)	25 (13 to 38)	25 (13 to 38)	31 (14.5 to 44)	31 (19 to 39.5)
IKDC score	49.4 (37.9 to 60.9)	46 (35.6 to 57.5)	44.8 (34.5 to 57.7)	47.1 (36.8 to 62.1)	47.1 (35.6 to 59.8)
EQ-5D index	0.69 (0.55 to 0.79)	0.68 (0.52 to 0.77)	0.67 (0.48 to 0.78)	0.68 (0.53 to 0.78)	0.67 (0.52 to 0.77)
EQ-5D VAS	75 (64 to 85)	75 (61.75 to 87)	75 (60 to 85)	76 (60.25 to 85)	75 (60 to 85)

ACL, anterior cruciate ligament; ADL, activities of daily living; EQ-5D, EuroQol five-dimension questionnaire; IKDC, International Knee Documentation Committee Subjective Knee Form; KOOS, Knee injury and Osteoarthritis Outcome Score; LM, lateral meniscus; MM, medial meniscus; PROM, patient-reported outcome measure; QoL, quality of life; VAS, visual analogue scale.

Table IV. Linear regression models with respect to preoperative patient-reported outcome measures, after adjusting for age, sex, chondral pathology, and time to surgery.

PROM	MM repair			MM resection			LM repair			LM resection		
	β	95% CI	p-value	β	95% CI	p-value	β	95% CI	p-value	β	95% CI	p-value
KOOS pain	-2.34	-4.9 to 0.22	0.073	-2.96	-5.54 to -0.38	0.024	-0.42	-3.71 to 2.87	0.802	-2.26	-5.26 to 0.74	0.14
KOOS symptoms	-3.26	-5.9 to -0.61	0.016	-2.76	-5.43 to -0.1	0.042	-1.94	-5.33 to 1.45	0.263	-2.85	-5.95 to 0.25	0.072
KOOS ADL	-2.38	-5.08 to 0.32	0.085	-2.78	-5.51 to -0.06	0.045	-1.22	-4.7 to 2.25	0.49	-2.07	-5.25 to 1.1	0.201
KOOS sport and recreation function	-3.51	-7.12 to 0.098	0.057	-2.92	-6.55 to 0.72	0.116	-1.06	-5.7 to 3.58	0.654	-2.2	-6.43 to 2.04	0.309
KOOS QoL	-3.85	-6.41 to -1.28	0.003	-2.7	-5.29 to -0.12	0.04	-0.5	-3.8 to 2.8	0.764	-1.54	-4.55 to 1.47	0.315
IKDC score	-2.94	-5.2 to -0.67	0.011	-3.15	-5.43 to -0.87	0.007	-1.56	-4.47 to 1.36	0.295	-2.45	-5.1 to 0.21	0.071
EQ-5D index	-0.01	-0.45 to 0.22	0.49	-0.025	-0.58 to 0.009	0.15	-0.004	-0.047 to 0.039	0.86	-0.013	-0.052 to 0.026	0.53
EQ-5D VAS	0.53	-2.19 to 3.26	0.701	-0.68	-3.43 to -5.19	0.625	-1.68	-5.19 to 1.82	0.347	-2.11	-5.31 to 1.09	0.196

ADL, activities of daily living; EQ-5D, EuroQol five-dimension questionnaire; IKDC, International Knee Documentation Committee; KOOS, Knee injury and Osteoarthritis Outcome Score; LM, lateral meniscus; MM, medial meniscus; PROM, patient-reported outcome measure; QoL, quality of life; VAS, visual analogue scale.

< 0.001). The lateral meniscus repair group was associated with worse KOOS sports and recreation scores at two years' follow-up (β = -4.264, p < 0.001). With regard to the five-year timepoint, no significant differences were demonstrated when the isolated ACL group was compared with either the medial or lateral meniscus groups (Table VIII). There was no statistically significant difference between meniscal resection groups and isolated ACLR group at two and five years' postoperative follow-up (Tables V to VIII).

Time from index injury to surgery

In a subgroup analysis evaluating the impact of time to surgery, participants undergoing surgical procedure within 12 weeks of the index injury demonstrated superior PROM scores with regard to IKDC, EQ-5D, and KOOS subscales, except KOOS symptoms, at two and five years (Supplementary Table i).

Table V. Knee injury and Osteoarthritis Outcome Score, EuroQol five-dimension questionnaire, and International Knee Documentation Committee scores among the groups at two years' follow-up. Data are presented as median (IQR).

PROM	Isolated ACL surgery (n = 2,423)	ACL + MM repair (n = 604)	ACL + MM resection (n = 625)	ACL + LM repair (n = 334)	ACL + LM resection (n = 414)
KOOS pain	94 (83 to 100)	92 (81 to 97)	94 (83 to 100)	94 (83 to 97)	94 (86 to 97)
KOOS symptoms	86 (75 to 96)	82 (68 to 93)	89 (75 to 96)	86 (71 to 93)	86 (75 to 93)
KOOS ADL	99 (94 to 100)	99 (91 to 100)	99 (93 to 100)	99 (94 to 100)	99 (94 to 100)
KOOS sport and recreation function	85 (70 to 95)	80 (65 to 95)	85 (70 to 100)	80 (65 to 95)	85 (70 to 95)
KOOS QoL	75 (56 to 88)	69 (50 to 88)	75 (56 to 88)	75 (50 to 88)	75 (56 to 88)
IKDC score	85.1 (72.4 to 94.3)	82.2 (66.7 to 92)	83.9 (69 to 93.1)	83.9 (70.1 to 92)	83.9 (72.4 to 94.3)
EQ-5D index	0.88 (0.77 to 1)	0.84 (0.74 to 1)	0.88 (0.74 to 1)	0.88 (0.77 to 1)	0.84 (0.77 to 1)
EQ-5D VAS	85 (76 to 91)	85 (75 to 90)	85 (75 to 91)	85 (75 to 91)	85 (75 to 90)

ACL, anterior cruciate ligament; ADL, activities of daily living; EQ-5D, EuroQol five-dimension questionnaire; IKDC, International Knee Documentation Committee; KOOS, Knee injury and Osteoarthritis Outcome Score; LM, lateral meniscus; MM, medial meniscus; QoL, quality of life; VAS, visual analogue scale.

Table VI. Knee injury and Osteoarthritis Outcome Score, EuroQol five-dimension questionnaire, and International Knee Documentation Committee scores among the groups at five years' follow-up. Data are presented as median (IQR).

PROM	Isolated ACL surgery (n = 2,423)	ACL + MM repair (n = 604)	ACL + MM resection (n = 625)	ACL + LM repair (n = 334)	ACL + LM resection (n = 414)
KOOS pain	94 (83 to 100)	94 (83 to 100)	94 (86 to 100)	94 (86 to 100)	92 (83 to 100)
KOOS symptoms	89 (75 to 96)	86 (71 to 93)	89 (75 to 96)	89 (75 to 93)	86 (71 to 96)
KOOS ADL	99 (93 to 100)	99 (93 to 100)	99 (94 to 100)	100 (96 to 100)	99 (92 to 100)
KOOS sport and recreation function	90 (70 to 95)	85 (65 to 95)	90 (70 to 100)	85 (75 to 100)	85 (67.5 to 95)
KOOS QoL	75 (56 to 94)	75 (56 to 88)	75 (63 to 94)	75 (56 to 94)	75 (50 to 94)
IKDC score	86.2 (71.3 to 94.3)	83.9 (69 to 93.1)	85.1 (70.1 to 93.1)	88.5 (74.7 to 95.4)	85.1 (65.5 to 94.3)
EQ-5D index	0.88 (0.77 to 1)	0.88 (0.77 to 1)	0.88 (0.77 to 1)	0.88 (0.77 to 1)	0.85 (0.74 to 1)
EQ-5D VAS	85 (76 to 91)	88 (80 to 92)	85 (78 to 91)	85 (80 to 93)	85 (75 to 90)

ACL, anterior cruciate ligament; ADL, activities of daily living; EQ-5D, EuroQol five-dimension questionnaire; IKDC, International Knee Documentation Committee; KOOS, Knee injury and Osteoarthritis Outcome Score; LM, lateral meniscus; MM, medial meniscus; PROM, patient-reported outcome; QoL, quality of life; VAS, visual analogue scale.

Discussion

The most important findings of our study were that, at two years post ACL reconstruction, patients undergoing concomitant medial or lateral meniscectomy had similar postoperative PROMs to patients undergoing isolated ACLR. Patients with concomitant LM repair had comparable PROMs, with the exception of KOOS sport and recreation subscale, and patients with concomitant MM repair had lower PROM scores across all KOOS subscales, IKDC, and EQ-5D index. However, at five years post ACL reconstruction, the scores were similar in all groups.

LaPrade et al[26] analyzed 4,691 primary ACLR patients from the Norwegian Ligament Registry. Akin to our observations, the authors reported lower preoperative KOOS scores, across all subscales, in patients with concomitant medial or lateral meniscal pathology compared to patients with isolated ACL injury. However, two-year postoperative KOOS showed no statistically significant difference between patients who had concomitant MM or LM surgery and those who only underwent isolated ACLR. The lone exception was the presence of lower KOOS symptoms and QoL scores in the MM repair group. In a retrospective cohort study of 6,138 primary ACLR patients, Svantesson et al[27] also reported that patients who underwent concomitant medial meniscal repair had lower KOOS symptoms and ADL scores at one-year follow-up compared to patients who had alternative or no meniscal procedures.

Subsequent surgeries resulting from failed meniscal repairs can adversely influence subjective clinical outcomes. Recent literature underscores a higher reoperation rate for meniscal repairs, particularly for the MM, leading to potentially diminished short-term clinical outcomes. Sarraj et al[28] demonstrated a 13.3% reoperation rate for concomitant meniscal repair compared to 0.08% for concomitant meniscal

Table VII. Linear regression models for patient-reported outcome measures at two years postoperatively, after adjusting for age, sex, chondral pathology, and time to surgery.

PROM	MM repair			MM resection			LM repair			LM resection		
	β	95% CI	p-value	β	95% CI	p-value	β	95% CI	p-value	β	95% CI	p-value
KOOS pain	-3.63	-5.526 to -1.736	< 0.001	-0.94	-2.85 to -0.97	0.335	-1.078	-3.51 to 1.36	0.385	0.368	-1.86 to 2.6	0.746
KOOS symptom	-4.88	-7.04 to -2.73	< 0.001	-0.26	-2.44 to 1.9	0.812	-2.584	-5.36 to 0.19	0.068	-1.01	-3.54 to 1.52	0.434
KOOS ADL	-2.43	-4 to -0.864	0.002	-1.29	-2.87 to 0.29	0.109	-0.26	-2.3 to 1.76	0.802	0.238	-1.6 to 2.08	0.80
KOOS sport and recreation function	-5.23	-8.173 to -2.28	< 0.001	-1.06	-4.021 to 1.909	0.485	-4.26	-8.05 to -0.5	0.027	-1.22	-4.7 to 2.23	0.488
KOOS QoL	-5.74	-8.886 to -2.59	< 0.001	-0.41	-3.583 to 2.76	0.798	-2.79	-6.834 to 1.258	0.177	-0.83	-4.52 to 2.86	0.661
IKDC score	-4.11	-6.483 to -1.726	< 0.001	-1.41	-3.801 to 0.989	0.250	-2.22	-5.29 to 0.835	0.154	-0.8	-3.59 to 1.997	0.577
EQ-5D index	-0.02	-0.47 to -0.002	0.037	0.01	-0.29 to 0.017	0.630	-0.01	-0.04 to 0.024	0.704	-0.003	-0.03 to 0.02	0.848
EQ-5D VAS	-1.34	-3.7 to 1.022	0.266	-0.93	-3.303 to 1.453	0.446	1.371	-1.67 to 4.405	0.376	0.031	-2.74 to 2.80	0.982

ADL, activities of daily living; EQ-5D, EuroQol five-dimension questionnaire; IKDC, International Knee Documentation Committee; KOOS, Knee injury and Osteoarthritis Outcome Score; LM, lateral meniscus; MM, medial meniscus; PROM, patient-reported outcome measure; QoL, quality of life; VAS, visual analogue scale.

Table VIII. Linear regression models for patient-reported outcome measures at five years postoperatively, after adjusting for age, sex, chondral pathology, and time to surgery.

PROM	MM repair			MM resection			LM repair			LM resection		
	β	95% CI	p-value	β	95% CI	p-value	β	95% CI	p-value	β	95% CI	p-value
KOOS pain	-1.08	-3.839 to 1.672	0.441	0.327	-2.45 to 3.102	0.817	0.943	-2.598 to 4.485	0.601	-0.275	-3.509 to 2.959	0.868
KOOS symptoms	-2.48	-5.64 to 0.678	0.124	-0.02	-3.2 to 3.165	0.992	0.283	-3.777 to 4.342	0.891	-1.149	-4.856 to 2.559	0.543
KOOS ADL	-0.80	-3.08 to 1.481	0.492	0.225	-2.07 to 2.52	0.847	0.331	-2.6 to 3.26	0.825	-0.168	-2.84 to 2.509	0.902
KOOS sport and recreation function	-2.15	-6.419 to 2.112	0.322	-0.66	-4.96 to 3.632	0.762	0.497	-4.960 to 3.632	0.859	-1.108	-6.114 to 3.898	0.664
KOOS QoL	-2.87	-7.362 to 1.621	0.210	1.155	-3.37 to 5.678	0.617	-0.2	-5.972 to 5.573	0.946	-1.472	-6.743 to 3.799	0.584
IKDC score	-1.8	-5.276 to 1.682	0.311	-0.05	-3.55 to 3.457	0.979	1.741	-2.730 to 6.211	0.445	-1.345	-5.427 to 2.738	0.518
EQ-5D index	-0.01	-0.037 to 0.027	0.751	0.00	-0.03 to 0.032	0.990	0.001	-0.04 to 0.042	0.948	0.001	-0.036 to 0.039	0.953
EQ-5D VAS	1.39	-1.345 to 4.115	0.320	-0.09	-2.84 to 2.662	0.950	-0.252	-3.760 to 3.257	0.888	-0.211	-3.415 to 2.993	0.897

ADL, activities of daily living; EQ-5D, EuroQol five-dimension questionnaire; KOOS, Knee injury and Osteoarthritis Outcome Score; LM, lateral meniscus; MM, medial meniscus; PROM, patient-reported outcome measure; QoL, quality of life; VAS, visual analogue scale.

resection in patients undergoing ACLR surgery. Rahardja et al[29] retrospectively reviewed 3,024 patients from the New Zealand ACL Registry undergoing ACLR with concomitant meniscal repair. The authors reported a reoperation rate of 8% and 5% for medial and lateral meniscal repairs respectively at 2.9 years postoperatively. Paxton et al[30] documented

reoperation rates of 12.4% and 8% at short-term follow-up for ACLR with concomitant MM and LM repair. Cristiani et al[31] investigated the clinical outcomes of ACLR with concomitant meniscal surgery in over 5,000 ACLR patients. The authors divided meniscal repair patients into two subgroups: successful meniscal repair group and failed meniscal repair group based on any further meniscal surgery following their index ACLR procedure. The failed meniscal repair group had significantly lower KOOS scores compared to the successful repair group among all KOOS subscales at one year postoperatively and lower KOOS symptoms at two years postoperatively.

Such findings support the theory that reoperations following unsuccessful meniscal repairs might be the driver for the diminished PROMs associated with MM repair in our study. The higher KOOS scores we observed in patients who underwent concomitant LM repair compared to those undergoing MM repair might possibly be attributed to higher rates of MM repair failure. There is reduced mobility of the MM compared to the LM,[26,32,33] and the MM acts as a secondary restraint to anterior tibial translation potentially exposing it to greater strain, especially when there is residual laxity following ACLR.[34]

Emphasizing meniscal preservation is crucial, as corroborated by previous biomechanical and clinical studies.[19,35] Therefore, efforts should invariably lean towards meniscal repair, especially during ACLR procedures, given the better clinical outcomes it offers over isolated repairs.[12,26] Our study, along with others focusing on short-term results, might inadvertently have overlooked the long-term ramifications of meniscal resections, perhaps casting a more favourable light on short-term outcomes of meniscal resection over meniscal repair.[36]

In our study, we noted no significant difference in PROM scores between concomitant MM or LM surgery groups (repair and resection) and isolated ACLR group at five years postoperatively. This observation aligns with reports from other large-scale studies. Ulstein et al,[37] analyzing 8,408 patients from the Norwegian and Swedish National Ligament Registries (NLR), observed similar five-year PROM scores between isolated ACLR patients and those with additional meniscal surgery, barring enhanced KOOS ADL. Conversely, results from the Multicenter Orthopaedic Outcomes Network (MOON) group showed worse IKDC and KOOS scores at six years postoperatively in patients requiring MM repair at the time of ACLR, compared to patients requiring LM repairs.[38] Furthermore, a ten-year follow-up study by Brophy et al[39] from the same cohort predicted worse IKDC (odds ratio (OR) 0.73, p = 0.004), KOOS symptoms (OR 0.73, p = 0.005), and KOOS QoL (OR 0.75,p = 0.014) in patients with ACLR and concomitant MM repair compared to LM repair. However, further work is needed to assess whether the biomechanical and clinical benefits of meniscal preservation previously suggested are borne out in long-term studies.[19]

Another finding was that patients with ACLR treated within 12 weeks of the index injury showed improved two- and five-year outcomes compared to those undergoing surgery after 12 weeks. Similar findings were noted in studies from the Swedish and Norwegian NLR.[21,40] The latter revealed a 1% monthly rise in cartilage lesion odds from injury to surgery.[40] In a large single-centre cohort study, Cance et al[41] reported that younger patients are at higher risk of chondral injury when ACLR is delayed. One potential determinant for superior outcomes could be that ACLR performed within 12 weeks might have enabled early surgical repair for associated meniscal tears. Venkatachalam et al[42] reported a 91% success rate for meniscal repair performed within three months post injury versus 58% for later repairs. However, some recent studies argue that the time gap between the injury and meniscal repair does not notably influence clinical outcomes.[43,44]

The strength of our study is its large sample size, diversity of the population, and use of a prospective national database enhancing the external validity of our study and suggesting applicability of our findings to community-based practices. However, there are several limitations that warrant consideration. As the study is based on registry data, variations are inherent in surgical approaches, the level of surgeon expertise, decision-making, and the adoption of rehabilitation protocols. Patients with concomitant meniscal repair may have adhered to different rehabilitation protocols including knee bracing with or without restriction in weightbearing to protect the meniscal repair,[45] potentially affecting the subjective outcome scores. However, recent studies have demonstrated no difference in clinical outcomes between accelerated and restrictive rehabilitation programmes following meniscal repair.[46] A significant proportion of patients in the NLR database were excluded from this study due to poor compliance with postoperative PROMs, potentially limiting the generalizability of the study's findings. Nevertheless, the patient and surgical characteristics of the included cohort in this study were similar to the larger NLR patient population.[47,48] Our study relied solely on subjective outcome scores without objective data or reoperation rates. The potential for selection bias of registry-based studies must also not be overlooked, especially considering the voluntary participation of surgeons and patients on the UK NLR.

This study showed that MM and to a lesser extent LM repairs, in combination with ACLR, were associated with inferior PROMs compared to isolated ACLR at two years postoperatively in a large UK registry, while meniscal resection groups exhibited comparable outcomes. Superior outcomes were noted when patients were treated within 12 weeks of the index injury. At five years, no significant differences in PROMs were evident. Further cross-sectional studies are warranted to investigate the longer-term outcomes of meniscal surgery alongside ACLR.

Supplementary material

Subgroup analysis for impact of time from injury to surgery on patient-reported outome measures.

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Author information

A. Gabr, MBChB, MRCS, MD(Res), FRCS (Orth), Dip SEM, Consultant Orthopaedic Surgeon,
West Suffolk Hospital NHS Trust, Bury St Edmunds, UK;
University College London Hospitals NHS Trust, London, UK.

A. Fontalis, MD (Dist), MSc (Res), MRCS (Eng), Specialist Trainee in Trauma & Orthopaedics
F. S. Haddad, BSc, MD, MCh, FRCS, FFSEM, Consultant Orthopaedic Surgeon
University College London Hospitals NHS Trust, London, UK.

J. Robinson, MBBS, MRCS, FRCS(Orth), Consultant Orthopaedic Surgeon, North Bristol NHS Trust, Bristol, UK.

W. Hage, FRCS(Orth), Consultant Orthopaedic Surgeon, North Cumbria NHS Trust, Cumbria, UK.

S. O'Leary, FRCS(Orth), Consultant Orthopaedic Surgeon, The Royal Berkshire Hospital NHS Trust, Reading, UK.

T. Spalding, FRCS(Orth), Consultant Orthopaedic Surgeon, Cleveland Clinic London, London, UK.

Author contributions

A. Gabr: Conceptualization, Formal analysis, Writing – original draft.
A. Fontalis: Conceptualization, Formal analysis, Writing – original draft.
J. Robinson: Supervision, Writing – review & editing.
W. Hage: Supervision, Writing – review & editing.
S. O'Leary: Supervision, Writing – review & editing.
T. Spalding: Supervision, Writing – review & editing.
F. S. Haddad: Supervision, Writing – review & editing.

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Data sharing

The data that support the findings for this study are available to other researchers from the corresponding author upon reasonable request.

Ethical review statement

This study did not require ethical committee approval as it only involved retrospective data analysis from data collected on the NLR. All patients on the NLR have signed informed consent allowing data utilisation for further clinical and research purposes. The study was approved by the NLR research committee. No patient contact was required, and no patient received any additional appointments, investigations, correspondence or any other contact from the study investigators.

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