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Concomitant meniscal injury in anterior cruciate ligament reconstruction does not lead to poorer short-term post-operative outcomes

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Abstract
Purpose The main objective was to compare post-operative outcomes in patients undergoing anterior cruciate ligament (ACL) reconstruction both with and without concomitant meniscus injury at a mean follow-up of 3.5 years. The secondary objective was to study the effect of different meniscal injury sites and treatment modalities on post-operative outcomes (PROS).
Methods This is a retrospective analysis of a prospectively maintained database of patients undergoing ACL reconstruction at our tertiary institution between 2009 and 2012. Age, sex, graft type, graft fixation modality, location of meniscal tear and treatment (meniscal repair or meniscectomy) were recorded in the database. PROS used included the Tegner activity scale and the Lysholm score.
Results There were no significant differences between patients with or without meniscal injury in terms of age, BMI or preoperative PROS. There was no significant difference in the post-operative outcome scores between patients with or without meniscal injury at a mean follow-up of 3.5 years. Regardless of the location of meniscal injury, the post-operative scores improved as compared to preoperative scores.
Conclusion Concomitant meniscal injury in cases of ACL reconstruction is not associated with poorer short-term post-operative PROS (mean follow-up time: 3.5 years). These findings may influence management decisions and help in preoperative counselling.
Level of evidence IV.

Keywords ACL · ACL reconstruction · Meniscus · Meniscectomy · Outcomes

Abbreviations

ACL	Anterior cruciate ligament
ACLR	Anterior cruciate ligament repair
LM	Lateral meniscus
MM	Medial meniscus
PROS	Patient-reported outcome scores
QoL	Quality of life
KOOS	Knee Injury and Osteoarthritis Outcome Score
SD	Standard deviation
BMI	Body mass index

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Introduction

ACL injuries tend to occur in sports involving jumping, pivoting and cutting manoeuvres [7]. Other joint structures may be injured in association with the ACL, with the meniscus being the most frequent [15]. Variable post-operative outcomes of ACL reconstruction (ACLR) in the presence of meniscal lesions have been reported in the literature. A study by Robb et al. [18] found that unrepaired concomitant meniscal injuries were significant predictors for ACLR failure. This is supported by other short-to-medium-term studies reporting lower patient-reported outcome scores (PROS) with concomitant ACLR and treatment for meniscal injury [11, 16, 19, 22]. However, there is also evidence that the presence of concomitant meniscal lesions, once repaired, do not affect post-operative ACLR PROS [3, 9–12, 14, 20]. Of the aforementioned studies, only LaPrade et al. [12] substratified their analyses according to the meniscal injury location and treatment method.

This study aims to evaluate post-operative outcomes of ACLR both with and without concomitant meniscus injury, as knowledge of these specific to the various injury subgroups may influence management decisions and aid preoperative counselling. The authors hypothesize that concomitant meniscal injury in ACLR leads to poorer short-term PROS. This is the first study conducted in an Asian cohort that compares outcomes of ACLR with meniscectomy against ACLR with meniscal repair.

Materials and methods

This is a retrospective analysis of a prospectively maintained database. Between January 2009 and December 2012, consecutive patients undergoing primary ACL reconstruction with quadrupled hamstring autograft at our institution were recruited. Informed consent was obtained during recruitment. Patients with multi-ligament knee injuries, concomitant knee injuries (apart from meniscal injury), revision ACLR or any previous knee surgeries were excluded from this study. Baseline characteristics such as age, sex, ACL graft type, graft fixation modalities, location of meniscal tear and meniscal treatment were recorded. A single meniscal injury was defined in cases of either a medial or a lateral meniscal injury. Combined medial and lateral meniscal injury was not considered to be 'single meniscal injury'.

Outcome measurement

Validated PROS—the Lysholm score and Tegner activity scale, were used to evaluate functional outcomes and assess level of physical activity [13, 18, 23]. Preoperatively, trained registry nurses administered the questionnaires to document baseline scores. Along with clinical examination, the same questionnaires were repeated at subsequent follow-up. If a patient missed a follow-up appointment, he/she was contacted via telephone, and the questionnaire was administered.

Treatment approach

All ACLRs were performed by surgeons trained in similar technique, using autologous four-strand hamstring grafts which comprised ipsilateral semitendinosus and gracilis tendons folded at the middle. To avoid confounding by fixation technique, only patients in whom suspensory fixation was used for femoral graft fixation and interference screws were used for tibial graft fixation were analysed. Meniscal injuries were documented at the time of surgery, and management ranged from: (1) no treatment, (2) repair or (3) partial meniscectomy. Repair was performed via an all-inside technique.

Post-operatively, all patients received appropriate analgesia and rehabilitation as per institution protocol. Patients who only underwent an ACLR were allowed to immediately full weight bear while keeping in a brace for 6 weeks with full range of motion. Patients who underwent concomitant meniscal repair, while also allowed to immediately full weight bear, were not permitted to flex their knee beyond 90° at 6 weeks post-operatively [1].

This study was approved by the National Healthcare Group Domain Specific Review Board (ID Number: 2014/1323) prior to commencement.

Statistical analysis

Descriptive statistics were used to report numerical variables, while *n* numbers and percentages were used to report categorical variables. Post-operative scores were compared on two levels. First, patients with isolated ACL injuries were compared to patients with concomitant meniscal injuries. Next, subanalysis of the treatment modality (meniscal repair versus meniscectomy) was performed for patients with either medial or lateral meniscal injuries. Patients with both medial and lateral meniscal injuries were excluded from this subanalysis, as the treatment may have differed for each injury. Wilcoxon signed-rank test was used to compare differences between preoperative and post-operative scores. The two-sample t test was used to compare the post-operative scores of patients with meniscal injury and of those without, as well as to compare between different treatment modalities. Bonferroni corrections were used for all groups. All statistical analyses were performed using Statistical Package for the Social Sciences (SPSS) version

22.0 (SPSS Inc, Chicago, IL, USA), and significance was defined as $p < 0.05$ throughout the study.

Results

The database yielded 390 ACLR patients, of whom 264 fulfilled inclusion criteria. One hundred and twenty-six patients with partial ACL tears, concomitant non-meniscal knee injuries, revision procedures, non-autologous tendon grafts, graft fixation methods different to those previously described or previous knee surgery were excluded from the study (Fig. 1). Ninety-four (24%) patients were lost to follow-up. The mean time interval from injury to surgery was approximately 4.5 months, with no significant difference between the ACL injury only group and ACL with meniscal injury group ($p = 0.463$). Fourteen (8%) of ACLR patients with meniscal injury did not receive any form of meniscal treatment.

No significance differences in baseline characteristics and preoperative PROS between comparison groups were found (Table 1). The presence of concomitant meniscal injury was not associated with significant differences in post-operative PROS when compared with cases of isolated ACL injury (Table 2). No statistically significant differences were observed for both Tegner and Lysholm scores ($p = 0.345$, and $p = 0.930$, respectively). The mean difference of Tegner activity level was 0.159 (95% CI −0.328 to 0.646), while the mean difference of Lysholm score was 0.904 (95% CI −3.215 to 5.023). Considering the clinical equivalence range as less than 1 unit difference for Tegner activity level, and less than 10 units difference in Lysholm score, the confidence intervals fell within these ranges and showed that there was a 95% probability of clinical equivalence between the two groups.

Comparing preoperative with post-operative PROS, every patient category showed improvements in the Tegner and Lysholm scores (Table 3a, b). No statistically significant differences in post-operative PROS were observed between meniscal repairs and meniscectomies (Table 4). The mean difference of Tegner activity level was −0.267 (95% CI −1.130 to 0.597), while the mean difference of

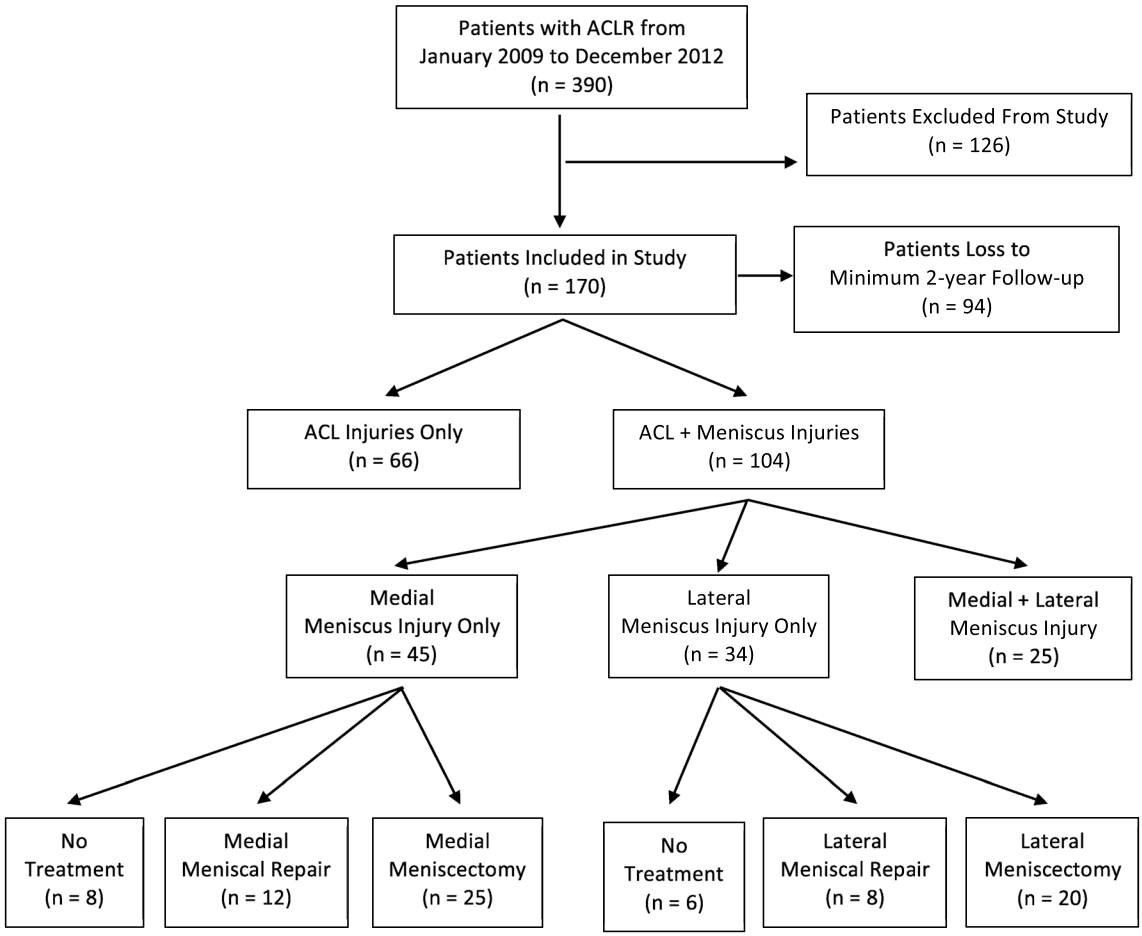

Fig. 1 Case selection and distribution

Table 1 Patient characteristics

Characteristics	Total ($n = 170$)	No meniscus injury ($n = 66$)	With meniscus injury ($n = 104$)	p value
Age	24.4 ± 6.4	24.3 ± 5.7	24.5 ± 6.8	n.s
Gender				n.s
Male	147 (86.5)	55 (83.3)	92 (88.5)	
Female	23 (13.5)	11 (16.7)	12 (11.5)	
Ethnicity				n.s
Chinese	97(57.1)	37 (56.1)	60 (57.7)	
Malay	43 (25.3)	18 (27.3)	25 (24.0)	
Indian	26 (15.3)	8 (12.1)	18(17.3)	
Others	4 (2.4)	3 (4.5)	1 (1.0)	
Body mass index (kg/m^2)	24.2 ± 3.8	23.6 ± 3.7	24.6 ± 3.8	n.s
Surgical duration (min)	92.9 ± 22.9	90.9 ± 22.1	94.2 ± 23.4	n.s
Scores				
Preinjury Tegner	7.52 ± 1.3	7.58 ± 1.20	7.49 ± 1.40	n.s
Preoperative Tegner	3.57 ± 2.0	3.45 ± 1.99	3.32 ± 1.98	
Lysholm	72.2 ± 17.0	68.9 ± 18.1	74.3 ± 16.1	

Table 2 Comparison of post-operative outcomes in patients with or without concomitant meniscus Injury (two-sample t test)

Post-operative outcomes	ACL injury alone ($n = 66$)	ACL + meniscus injury ($n = 104$)	p-value	Mean difference (95% CI)
Post-operative Tegner activity level	6.40 ± 1.57	6.25 ± 1.57	0.52	0.159 (−0.328 to 0.646)
Post-operative Lysholm score	88.7 ± 12.5	87.8 ± 13.5	0.665	0.904 (−3.215 to 5.023)

Table 3 Comparison of preoperative and post-operative scores in patients with isolated ACLR and ACLR with MM or LM or both MM and LM Injuries (Wilcoxon rank test)

Injury profile	ACL alone ($n = 66$)	ACL + MM ($n = 45$)	ACL + LM ($n = 34$)	ACL + both menisci ($n = 25$)
(a)				
Preinjury Tegner activity level	3.5 ± 2.0	3.5 ± 2.0	3.1 ± 2.0	3.3 ± 2.0
Post-operative Tegner activity level	6.4 ± 1.6	6.1 ± 1.5	6.3 ± 1.8	6.5 ± 1.4
% patients with improved Tegner scores	86.40%	77.80%	85.30%	88%
p value	<0.001	<0.001	<0.001	<0.001
(b)				
Preinjury Lysholm score	66.9 ± 18.0	72.7 ± 16.2	77.2 ± 16.3	71.7 ± 16.6
Post-operative Lysholm score	88.7 ± 12.5	87.9 ± 12.2	88.1 ± 14.8	86.9 ± 13.2
% patients with improved Lysholm scores	83.30%	77.80%	73.50%	76%
p value	<0.001	<0.001	n.s	n.s

Table 4 Comparison of post-operative outcomes of meniscal repair versus meniscectomy in patients with concomitant medial or lateral meniscus injuries (combined medial and lateral meniscus injuries excluded) (two-sample t test)

Post-operative outcomes	Meniscal repair ($n = 20$)	Meniscectomy ($n = 45$)	p value	Mean difference (95% CI)
Post-operative Tegner activity level	6.0 ± 1.5	6.3 ± 1.6	0.539	−0.267 (−1.130 to 0.597)
Post-operative Lysholm score	88.0 ± 13.1	89.4 ± 13.3	0.672	−1.517 (−8.647 to 5.614)

Lysholm score was −1.517 (95% CI −8.647 to 5.614). However, as the 95% confidence intervals for the difference in scores between these groups exceeded the clinical equivalence range of 1-unit difference for Tegner score and 10-unit difference for Lysholm score, this comparison was underpowered to confirm clinical equivalence in this regard.

ACLR patients with either concomitant medial or lateral meniscectomy had significant improvements in Tegner scores from preoperative to post-operative activity levels (Table 5a), while ACLR patients with concomitant medial meniscectomy had significant improvements in Lysholm scores when comparing preoperative with post-operative outcomes (Table 5b).

Discussion

The most important finding of the present study was that at a mean of 3.5 years post-operatively, patients with isolated ACL tears and those with concomitant meniscal injury showed no significant difference in post-operative outcomes. In the existing literature, the impact of meniscal injuries on short- and medium-term ACLR outcomes remains unclear.

While meniscal injury observed at the time of ACLR has been suggested to affect post-operative functional outcomes, some studies have reported worse post-operative outcome scores [3, 9, 11], whereas others show no significant difference [10, 12, 14, 20]. Some studies suggest that preserving meniscus tissue and function correlates with successful long-term ACLR outcomes [5, 16]. The most important finding of the present study was that at mean follow-up of 3.5 years, patients who had undergone isolated ACLR did not have better post-operative outcomes compared to those with concomitant ACLR and meniscal injury.

Meniscal tear location and meniscal treatment modality did not appear to influence post-operative PROS in our study. In our results, all patient subgroups, based on meniscal injury location and treatment modality, showed improvements in their post-operative Tegner and Lysholm scores. Statistical significance was not reached in some of these subgroups, namely the medial meniscus repair and lateral meniscus repair groups, though the authors believe this may have been due to the small sample sizes of those groups.

With regards to meniscal tear location, La Prade noted significantly lower post-operative scores on the KOOS Other Symptoms and QoL subscales for MM repair patients and those with LM tears [12]. This could be attributed to difficult approach to the lateral compartment space, thus explaining the generally poor post-operative outcomes for LM injury regardless of treatment [6]. LM injuries likely occur acutely during the time of ACL injury, while MM injuries usually develop subsequently, over a more chronic timeframe, as a result of increased stress from anterior tibial translation which occurs in an ACL-deficient knee [4]. To minimize confounding, preoperative PROS were collated just prior to operation, so that negative clinical effects of any MM injury that might have developed between time of injury to time of surgery (mean of 4.5 months) could be picked up.

Our results also did not yield any significant differences in PROS when comparing cases of meniscal repair with cases of meniscectomy. This may be due to the inadequate power in our subgroup analysis. Future studies should have a larger cohort of patients to investigate whether this trend changes with long-term follow-up, and also consider the use of imaging modalities such as MRI during follow-up,

Table 5 Comparison of preoperative and post-operative (a) Tegner activity level by site of meniscal injury and treatment (Wilcoxon rank test). (b) Lysholm score by site of meniscal injury and treatment (Wilcoxon rank test)

	Medial meniscus		Lateral meniscus	
	Meniscal repair ($n = 12$)	Meniscectomy ($n = 25$)	Meniscal repair ($n = 8$)	Meniscectomy ($n = 20$)
(a)				
Preoperative Tegner activity level	3.1 ± 2.0	3.7 ± 2.1	2.8 ± 1.3	3.3 ± 2.0
Post-operative Tegner activity level	6.3 ± 1.7	5.9 ± 1.6	5.5 ± 1.2	6.7 ± 1.7
% patients with improved Tegner score	91.70%	72%	87.50%	85%
p value	n.s	<0.001	n.s	<0.001
(b)				
Preoperative Lysholm score	74.9 ± 19.9	70.1 ± 15.5	78.8 ± 11.2	73.7 ± 18.7
Post-operative Lysholm score	90.2 ± 13.6	90.1 ± 13.6	84.6 ± 12.5	88.6 ± 13.3
% patients with improved Lysholm score	75%	84%	62.5%	85%
p value	n.s	<0.001	n.s	n.s

so as to provide more objective outcome measures to compare meniscal repair with meniscectomy. This would allow careful evaluation of the menisci, as it has been previously established that meniscal injury accelerates osteoarthritis, independent of the outcome of ACLR in restoring knee function [17, 21].

While the present study is smaller than La Prade et al.'s, it is only the second study to compare subgroups according to both meniscal injury location and treatment modality in such a cohort [12]. Therefore, it adds more evidence to the currently scarce literature on short-to-medium-term outcomes in such a patient group. Furthermore, this study is the first of its kind to be conducted in an Asian patient cohort, and this is a salient point as Asians generally have greater ligamentous laxity and joint mobility than Caucasians, a phenotypic difference that could potentially affect patients both pre- and post-operatively [8].

While La Prade et al. used the KOOS Other Symptoms and QoL subscales outcome scores, we chose to use the Tegner and Lysholm methods of assessment as they have been shown to have good retest reliability [2, 12, 13, 18, 19, 23]. The lack of significant differences in post-operative PROS observed in this study is consistent with results from previous studies using similar scoring systems [3, 22]. The findings of this study may influence management decisions in cases of ACL injury with concomitant meniscal injury, and improve preoperative counselling for such patients by providing them with better understanding of possible short-term outcomes.

Conclusion

At a mean of 3.5 years post-operatively, patients with isolated ACL tears and those with concomitant meniscus injury had comparable PROS following ACLR. Regardless of site of injury and treatment modality, all patients showed improvement in their post-operative PROS.

Author's Contributions AS participated in the study design, supervised data collection and drafted the manuscript. DW and CT participated in data collection. SL facilitated acquisition of data and performed statistical analysis together with SG. KAT participated in data collection, assisted with statistical analysis and drafting of the manuscript and provided critical revision of the manuscript. BC participated in data collection, was involved in data interpretation and helped in drafting the manuscript. LK conceived and designed the study, supervised the team, facilitated acquisition of the data and provided direction for and critical review of the manuscript. All authors read and approved the final manuscript.

Compliance with ethical standards

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Conflict of interest The authors declare that they have no conflict of interest.

Ethical approval Ethics approval was obtained from the National Healthcare Group Domain Specific Review Board (ID Number: 2014/1323).

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