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The Occurrence of Meniscal and Chondral Injury in Two-Stage Revision Anterior Cruciate Ligament Reconstruction: A Consecutive Case Series

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Abstract

Two-stage revision anterior cruciate ligament (ACL) reconstruction is an effective way to revise suboptimal tunnel-placement allowing for proper graft fixation. However, prolonged increased laxity of the knee may increase the risk of meniscal or chondral injury. It was hypothesized that no additional meniscal or chondral lesions occur in between the two stages of the two-stage revision ACL reconstruction. In this retrospective study, 42 patients undergoing a two-stage revision ACL reconstruction were included. Surgical notes for both stages were screened for meniscal and chondral status, interventions to any concurrent injury, surgery dates, along with basic patient characteristics. In 4 of the 42 patients, a new meniscal tear occurred in between the two stages, of which three required partial meniscectomy during the second stage of the ACL revision. One patient experienced a new small degenerative tear that did not require intervention. Two out of the four menisci that were repaired during the first stage had failed and required partial meniscectomy. No significant difference was found in the time between the two stages with respect to the occurrence of meniscal tears. No significant differences in chondral status were found. In conclusion, approximately 10% of patients developed a new meniscal tear and no difference in macroscopic chondral injury was observed between the first and second stages.

Keywords
- revision anterior cruciate ligament reconstruction
- meniscal tears
- two-stage revision
- bone grafting

Failure rates as high as 18% have been described after primary anterior cruciate ligament (ACL) reconstruction, which may require a revision procedure.[1,2] One of the main causes of failure of primary ACL reconstruction is malpositioning of the tunnels.[1,3–5] Malpositioning of the tunnels can interfere with the desired tunnel placement during revision ACL reconstruction, compromising on adequate bone quality, necessary for proper graft fixation.[6]

To ensure adequate bone quality for graft fixation, a two-stage ACL revision technique has been proposed.[7–10] According to the literature approximately 9% of the revision ACL reconstruction cases are performed in this manner.[5] During the first stage, arthroscopic debridement of the old graft is performed, and concurrent meniscal injuries and chondral lesions are treated. The original bone tunnels are drilled and filled with bone graft.[11] The first stage is followed by a rehabilitation phase of approximately 4 to 6 months[7] to allow for bone healing. Using this technique, bone stock is optimized before arthroscopic revision ACL reconstruction that is performed in the second stage, which is much alike a primary ACL reconstruction in this manner. However, during the bone graft healing/incorporation period, the knee joint is subject to a prolonged time of increased laxity between the first and second stages.[6] Several groups have shown that increased time between graft failure and revision

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ACL reconstruction may be correlated with increased risk for meniscal and chondral lesions.[12–14] However, no prior studies have assessed the occurrence of meniscal and chondral lesions in two-stage revision ACL surgery.

Therefore, in the present study, we aimed to assess meniscal and chondral lesions with two known points in time (i.e., first stage and second stage surgery) in patients undergoing two-stage revision ACL reconstruction. We hypothesized that no additional meniscal or chondral lesions occur in these patients.

Methods

Patients

This is a retrospective analysis of all consecutive patients that underwent a two-stage revision ACL reconstruction at the department of orthopaedics in our hospital between September 2003 and June 2017, regardless of concomitant meniscal/chondral injury and/or laxity of the knee. Patients were excluded from analysis if the operation report of either the first or second stage was unavailable. No other exclusion criteria were applied. All procedures were performed by two senior sports surgeons (J.W.A.S. and E.R.A.v.A.). Indication for revision ACL reconstruction was recurrent symptomatic instability after primary ACL reconstruction, confirmed by increased anteroposterior (AP) translation of the knee during physical examination (using Lachman's test and pivot shift test). In our population, the indication for the two-stage procedure was either incorrect previous tunnel position (for instance vertical graft orientation[3]) or enlargement of tibial or femoral tunnels compared with primary reconstruction (10–12 mm or wider).[15] This study was approved by our institutional review board (protocol no.: 16–116).

Preoperative Assessment

All patients received standard radiographic evaluation of the knee (i.e., AP and lateral radiographs). This was done for both the assessment of osteoarthritis and to enable comparison with radiographs prior to the second stage to assess bone incorporation. All patients received magnetic resonance imaging (MRI) scans to confirm ACL rupture and also examine menisci, cartilage, and other ligaments of the knee. In cases where tunnel positioning and possible tunnel enlargement could not be properly examined by MRI, an additional computed tomography (CT) scan was made.

Surgical Technique

The two-stage revision ACL reconstruction has been described in detail elsewhere.[6,7,11,16] During the first stage, all hardware interfering with tunnel-placement were removed and old bone tunnels were drilled out and filled with allograft bone dowels. Treatment to any concurrent meniscal or chondral injury was left to the discretion of the treating physician. After proper bone graft incorporation, assessed with radiographs in between the two stages, a routine ACL reconstruction was performed using either tibialis anterior or tibialis posterior tendon allograft. Meniscal repair on the posterior horn was performed using an all-inside technique by Smith & Nephew. On the body and anterior horn an inside-out technique by Arthrex was used. Patients were not routinely braced postoperatively.

Assessment

Patient's medical records were screened for baseline characteristics (date of birth, gender, weight, and height). The date of their primary reconstruction was noted, or in case of a rerevision, the date of their most recent reconstruction. Operation reports of both stages were evaluated for the date of the procedure, findings of physical examination under anesthesia (Lachman, anterior drawer, pivot shift, medial collateral laxity, and lateral collateral laxity), chondral status according to the Outerbridge's classification[17] for all six compartments (posterior side of patella, trochlea, medial femoral condyle, medial tibial platea, lateral femoral condyle, and lateral tibial plateau), assessment of both menisci (using the ISAKOS [International Society of Arthroscopy, Knee Surgery, and Orthopaedic Sports Medicine] classification[18] when available), any intervention concerning the menisci, and presence of synovitis. Patients' medical records were screened for possible adverse events concerning the bone grafting or any trauma occurring between the first and second stages.

Statistical Analysis

IBM SPSS Statistics for Macintosh, version 24.0 (Armonk, NY: IBM Corp) was used for statistical analysis of the data. Descriptive statistics were used for baseline characteristics exploration. Logistic regression was used to investigate whether time between the two stages predisposed for the occurrence of a new meniscal tear or the requirement of reintervention to a previously treated meniscal tear. A paired *t*-test was used to compare chondral status between the first and second stages. A linear regression was used to evaluate correlation between time between the two stages or body mass index (BMI) and progression of chondral injury.

Results

Between September 2003 and June 2017, 96 patients underwent revision ACL reconstruction of which 42 in a two-stage approach (►**Fig. 1**). Twenty-four patients were male and 18 were female with a mean (± standard deviation [SD]) age of 26.7 ± 7.8 and a mean BMI of 25.1 ± 4.1. No patients were lost to follow-up. The mean time between the primary or most recent ACL reconstruction and failure of the ACL reconstruction was 1.7 ± 2.1 years. The mean time between the first and second stage of the revision ACL reconstruction was 21 ± 10 weeks (range: 9–58 weeks). Trauma to the knee between the first and second stage or adverse events related to the bone grafting were not reported in any patient.

Nine medial meniscal tears and four lateral meniscal tears were found at the first stage in 10 patients (23.8%). Of these 13 tears, 4 (three medial, one lateral) were repaired, 7 underwent partial meniscectomy (five medial, two lateral), and 2 tears were left untouched due to their degenerative aspect and size. At the time of the second stage, four (9.5%) new lateral meniscal tears were found between the first

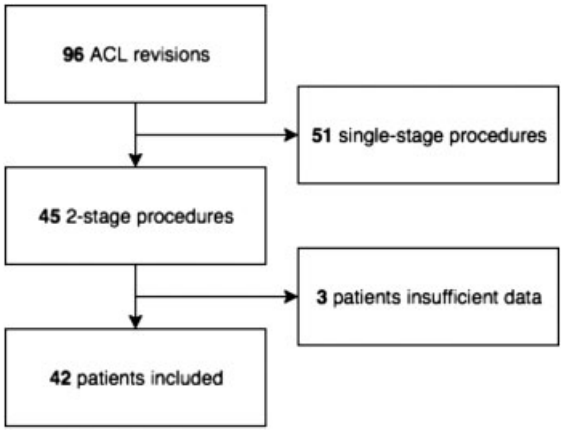

Fig. 1 Flowchart for patient inclusion.

and second stage in four patients of which three patients required a partial meniscectomy. No new tears to the medial meniscus were observed between the two stages. Two previously treated tears required reintervention in both cases due to failure of the meniscal repair for medial meniscus tears during the first stage (►**Table 1**). None of the patients, with either a new tear in between the two stages or a failed meniscal repair, had any concurrent laxity in the medial collateral ligament (MCL) or the lateral collateral ligament (LCL) during the first procedure.

Logistic regression analyses showed that time between the first and the second stages was not significantly correlated to either a reintervention to a previously treated meniscal tear or the development of a new meniscal tear ($p = 0.148$).

Table 2 Mean Outerbridge classifications for all compartments during first and second stages

	First stage	Second stage	*p*-Value
Retropatellar	0.220	0.256	0.715
Trochlea	0.700	0.000	0.083
Medial tibial plateau	0.210	0.286	0.421
Medial condyle	0.405	0.417	0.921
Lateral tibial plateau	0.170	0.085	0.164
Lateral condyle	0.155	0.179	0.750

No significant differences were found in chondral injury between the first and second stages for all six compartments (►**Table 2**). Time between the two stages was not a significant predictor for an increase in chondral injury in all six compartments.

Discussion

The most important finding in our study was that between the two stages, 4 out of 42 (9.5%) patients developed a new meniscal tear. Three of these patients required an intervention during the second stage. The time between the first and second stages was not correlated to the occurrence of these tears. No difference in chondral injury was noted between the two stages. Two out of four meniscal repairs from the first stage failed and required a partial meniscectomy during the second stage.

Table 1 The occurrence and treatment of meniscal tears during both the first and second stages

		Meniscus during phase 1	Action during phase 1	Meniscus during phase 2	Action during phase 2
1	Lateral	Normal meniscus	None	Horizontal tear	Partial meniscectomy
2	Medial	Large flap tear	Partial meniscectomy	Postmeniscectomy	None
3	Lateral	Normal meniscus	None	Flap tear	Partial meniscectomy
4	Medial	Bucket-handle tear	Meniscal repair	Failed repair	Partial meniscectomy
5	Medial	Radial tear	Partial meniscectomy	Post-meniscectomy	None
6	Medial	Bucket-handle tear	Meniscal repair	Failed repair	Partial meniscectomy
7	Medial	Degenerative tear	Partial meniscectomy	Postmeniscectomy	None
	Lateral	Normal meniscus	None	Degenerative tear	None
8	Lateral	Normal meniscus	None	Flap tear	Partial meniscectomy
9	Medial	Degenerative tear	Partial meniscectomy	Postmeniscectomy	None
	Lateral	Flap tear	Partial meniscectomy	Post-meniscectomy	None
10	Medial	Horizontal tear	Meniscal repair	Successful repair	None
	Lateral	Unspecified tear	None	Unspecified tear	None
11	Medial	Degenerative tear	None	Degenerative tear	None
12	Lateral	Root tear	Meniscal repair	Successful repair	None
13	Medial	Old bucket-handle tear	Partial meniscectomy	Small residual tear	None
	Lateral	Radial tear	Partial meniscectomy	Postmeniscectomy	None

Two studies reported a total incidence of 20 to 40% of new meniscal tears in revision ACL patients.[14,19] Another study showed that in patients with conservative treatment of an ACL rupture, 64% requires surgical intervention to their meniscus within 2 years.[20] Ten (23.8%) of our patients had a new or old meniscal tear at the time of the first procedure, and in 4 (9.5%) patients a new meniscal tear had occurred in between the two stages. This makes the cumulative incidence of meniscal tears in our cohort in agreement with previously published literature on meniscal tears in ACL deficient patients. Interestingly, all new meniscal tears were observed in the lateral compartment of the knee. This is in concordance with previous literature that suggests that the lateral meniscus plays a stabilizing role during tibial internal rotation.[21] In healthy patients, the ACL acts as a secondary restraint for tibial internal rotation. Increased rotational laxity in ACL deficient patients may therefore contribute to increased stress of the lateral meniscus, potentially leading to injury. Even though medial meniscal injuries can also occur due to the medial meniscus acting as a secondary restraint in tibial anteroposterior translation, none were observed within our population.[22]

Three studies previously investigated the occurrence of meniscal and chondral injury in patients requiring a revision ACL reconstruction and correlated this to the timing of the revision surgery.[12–14] Church and Keating[13] and Diamantopoulos et al[12] found a significant difference in meniscal tears between early and delayed revision ACL reconstruction, defined as reconstruction $>$ 12 months after reinjury.[13] However, they failed to distinguish between new meniscal tears and preexistent tears, making it difficult to interpret the relation between surgery timing and the occurrence of meniscal tears. Similar to our findings, Ohly et al[14] investigated new meniscal tears separately and found no difference in the incidence of meniscal tears between early and delayed revision ACL reconstruction, delayed reconstruction defined as $>$ 6 months after reinjury.[14] In contrast to our findings, however, previous studies found significant differences in cartilage degeneration between early and delayed revision ACL reconstruction.[12–14] An explanation for these contradictive findings might be that almost all of our patients received the second stage procedure within 6 months after the first, not allowing enough time for any chondral insult and resulting injury to occur.

It is commonly reported that subjective outcome measures of revision procedures remain inferior to primary ACL reconstructions.[23–25] Some authors suggest this might be due to a higher incidence of meniscal and chondral lesions in revision patients.[6,26] Because of presumed higher numbers of meniscal and chondral lesions in two-stage ACL revision, some authors advocate caution choosing a staged procedure as opposed to a single procedure.[6,27] A recent study by Mitchell et al, however, showed no difference in subjective outcomes between patients treated with a one or a two-stage revision ACL reconstruction.[28] The fact that in this study, no difference was observed in chondral status in between the two stages, also advocates against chondral lesions as a potential driver for inferior subjective results in two-stage revision ACL reconstruction.

In this study, four meniscal repairs were performed during the first stage of which two required a reintervention in the form of a partial meniscectomy during the second stage. Overall success rates for meniscal repair in instable knees have been reported varying from 30 to 70%.[29] The fact that in our population 50% of the meniscal repairs failed suggests that performing meniscal repair simultaneously with the first stage of a two-stage ACL revision does not seem to further increase the risk of meniscal repair failure. Several studies have reported conflicting findings on this topic. A previous study performed by Steenbrugge et al showed that chances of failure of meniscal repair are up to four times higher in patients with ACL deficient knees compared with patients with an intact ACL.[30] In contrast to these findings, Tucciarone et al more recently showed a slight advantage favoring ACL deficient knees when it comes to meniscal repair success percentage.[31] As the failure rate for meniscal repairs in this population is in concordance with overall failure rates, the authors do not advise against performing meniscal repair during the first phase. Furthermore, as patients require a second intervention for their ACL reconstruction, regardless failure of a meniscal repair does not increase patient burden in terms of additional procedures whereas successful meniscal repair allows maximum preservation of meniscal function.

The main strength of this study is its unique set-up, enabling us to specifically investigate the occurrence of meniscal and chondral injury and the correlation with surgery timing in patients undergoing a two-stage revision ACL reconstruction. To our knowledge, this is the first study to make a direct comparison in chondral and meniscal status in between the two stages in the two-stage revision ACL reconstruction.

There are several limitations to this study. First, this is a retrospective study, and in some cases, we were unable to extract all the items from patient charts. Second, only 42 patients were studied which limits the statistical power of our study. Third, the time between the first and second stage varied among patients. The time between the two stages was predominantly based on the size of the old tibial and femoral tunnels that had to be filled. Every patient, however, received radiographs before the second procedure to confirm bone graft incorporation. Therefore, we do not expect this variability to influence our results. Lastly, because the meniscal and chondral status were assessed macroscopically during the arthroscopic procedure, these data may be subject to some variability due to the subjective nature of scoring.

Conclusion

In conclusion, approximately 10% of patients developed a new meniscal tear and no difference in macroscopic chondral injury was observed between the first and second stage of two-stage revision ACL reconstruction. Two-stage revision ACL reconstruction should be reserved for patients not suitable for a single-stage procedure.

Authors' Contributions

Study conception and design: F.R.v.T., W.A.K., S.K.v.d.V., and E.R.A.v.A.

Acquisition of data: F.R.v.T.
Analysis and interpretation of data: F.R.v.T., W.A.K., and S. K.v.d.V.
Drafting of manuscript: F.R.v.T., W.A.K., and S.K.v.d.V.
Critical revision: W.A.K., S.K.v.d.V., R.J.P.v.d.W., J.W.A.S., and E.R.A.A.
Apporval of final version: F.R.v.T., W.A.K., S.K.v.d.V., R.J.P.v. d.W., J.W.A.S., and E.R.A.A.

Conflict of Interest
None declared.

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