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ORIGINAL ARTICLE

Third time's a charm?: improving re-revision ACL reconstruction by addressing reasons for prior failures

Robert A. Magnussen · Sébastien Lustig · Guillaume Demey · Ahmed ElGuindy · Elvire Servien · Philippe Neyret

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Abstract
Purpose The purpose of this study was to determine whether re-revision anterior cruciate ligament (ACL) reconstruction including careful assessment and treatment of reason for prior failures decreases knee laxity and improves International Knee Documentation Committee (IKDC) scores.
Methods Re-revision ACL reconstructions were performed in eight patients at a mean age of 29.6±6.9 years. All reported subjective knee instability preoperatively and demonstrated objectively increased laxity on physical examination and Lachman stress radiographs. Reasons for failure of the prior revision reconstructions were classified as tunnel malposition (two), associated posteromedial (one) or posterolateral (one) laxity, excessive tibial slope (one), and recurrent trauma (three). Specific steps were taken to address reasons for prior failure, including correcting malpositioned tunnels (two cases), posteromedial reefing (one case), posterolateral corner reconstruction (one case), or tibial deflexion osteotomy (one case). Follow-up evaluation included physical examination, radiographic evaluation including Lachman stress views, and a subjective IKDC evaluation.
Results Seven patients were available for follow-up at 4.4±2.3 years postoperative. Lachman examination improved with surgery in five patients and was unchanged in two patients (p=0.013). The pivot shift examination, improved in five patients, was unchanged in one patient and worsened in one patient (p=0.33). Two graft failures were diagnosed based on physical examination findings. Anterior tibial translation on stress radiographs decreased in all patients. The mean value decreased from 8.3±2.9 to 3.0±2.6 mm (p=0.0025). The postoperative subjective IKDC score was 56.9±16.9. Overall IKDC score improved in all patients.
Conclusion Re-revision ACL reconstruction including identification and treatment of reasons for prior failure results in improved knee laxity and IKDC scores.

Keywords Anterior cruciate ligament · Revision · Re-revision · Lateral extra-articular reconstruction

Level of Evidence: Case Series—Level IV

R. A. Magnussen (✉)
Department of Orthopaedic Surgery,
The Ohio State University School of Medicine,
Columbus, OH, USA
e-mail: robert.magnussen@gmail.com

S. Lustig · G. Demey · E. Servien · P. Neyret
Department of Orthopaedic Surgery,
Hôpital de la Croix-Rousse,
Centre Albert Trillat,
Lyon, France

A. ElGuindy
Department of Orthopaedic Surgery, Faculty of Medicine,
Fayoum University,
Fayoum, Egypt

Introduction

The anterior cruciate ligament (ACL) is commonly injured and its reconstruction is among the most commonly performed orthopedic procedures [1]. Modern ACL reconstruction techniques allow clinically stable ligament reconstruction in the majority of cases; however, failed reconstruction continues to be a problem. Failure rates of revision ACL reconstruction based on significantly abnormal Lachman and pivot shift have ranged from 2% to 28% at minimum 5-year follow-up [2–7]. Revision rates in these same series were reported to be between 2% and 10% [2–7].

Several large series reporting the results of revision ACL reconstruction have been published, with generally poorer results noted than in cases of primary reconstruction [8–12]. Poorer outcomes are likely secondary to poorer control of tibial translation and rotation following revision surgery as well as the

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increased incidence of meniscal and articular cartilage injuries noted in this population [8, 9, 13–15]. Failure rates of revision ACL reconstruction based on significantly abnormal Lachman and pivot shift have been reported between 6% and 36% [8–12].

In spite of the relatively high rates of clinical failure of revision ACL reconstruction, additional reconstructive procedures are relatively rarely performed [9, 11]. The reasons for this discrepancy are likely multiple and include decreased patient activity level and expectations, patients' hesitation to undergo another surgical procedure, and concern on the part of surgeons and patients as to whether a re-revision would improve functional results.

Numerous authors have stressed the successful revision ACL reconstruction depends on identification and treatment of the reason for failure of the primary reconstruction [9, 13, 15]. We hypothesize that re-revision ACL reconstruction results in improved knee stability and overall International Knee Documentation Committee (IKDC) scores when reasons for failure of the prior reconstructions are identified and addressed.

Methods

Patients

Ninety-one revision ACL reconstructions were performed at out center between 2002 and 2009. Eight of these patients were re-revision ACL reconstructions. These eight patients form the study group. Mean patient age at surgery was 29.6 ±6.9 years (range, 19.4 to 35.1 years). All patients reported subjective knee instability preoperatively. Four patients reported instability as their only symptom, while four patients reported pain as their primary symptom and noted instability as well. All eight were noted on physical exam to have a positive pivot shift and/or soft endpoint on the Lachman examination as well as increased anterior tibial translation on stress (Lachman) radiographs. Reasons for failure of the prior revision reconstructions were classified as tunnel malposition as noted on 3-D reconstruction of CT images (two), associated posteromedial (one) or posterolateral (one) laxity, excessive tibial slope (one), and recurrent trauma (three).

Surgical technique

Each patient underwent arthroscopic-assisted two-incision ACL reconstruction. Femoral fixation was achieved through a press-fit technique while tibial fixation was performed with an absorbable interference screw and backup cortical fixation with a screw and metallic wire [16–18]. Autograft tissue was used in all cases including one ipsilateral patellar tendon graft, five contralateral patellar tendon grafts, and two ipsilateral quadriceps tendon grafts (Table 1).

Table 1 ACL graft utilized

Patient	Primary reconstruction	Revision reconstruction	Re-revision reconstruction
1	Ipsilateral patellar tendon	Ipsilateral hamstring	Contralateral patellar tendon[a]
2	Ipsilateral patellar tendon	Contralateral patellar tendon[a]	Ipsilateral quadriceps tendon
3	Ipsilateral patellar tendon	Ipsilateral patellar tendon	Contralateral patellar tendon
4	Ipsilateral hamstring	Ipsilateral patellar tendon	Contralateral patellar tendon
5	Ipsilateral patellar tendon	Contralateral patellar tendon[a]	Ipsilateral patellar tendon
6	Ipsilateral patellar tendon	Contralateral patellar tendon[a]	Ipsilateral quadriceps tendon
7	Ipsilateral patellar tendon	Ipsilateral hamstring	Contralateral patellar tendon[a]
8	Synthetic graft	Ipsilateral patellar tendon	Contralateral patellar tendon[a]

[a] Associated extra-articular reconstruction performed

In each patient, specific steps were taken to address the reason for prior failure. Correction of malpositioned tunnels was performed in two patients. These included one case of a vertical femoral tunnel (Fig. 1) and one case of a too posterior tibial tunnel. In both cases, the previous tunnel was sufficiently malpositioned that a new tunnel could be drilled without tunnel convergence. Posteromedial reefing was performed in one patient with posteromedial instability. The technique consisted of a proximal advancement of the origin of the posteromedial capsule on the medial femoral metaphysis [19]. Posterolateral corner reconstruction according to the technique of Sekiya et al. was performed in one patient with associated posterolateral instability [20]. A tibial deflexion osteotomy was performed in one patient with excessive tibial slope using a technique previously described [21]. Concurrent valgus-producing high tibial osteotomy was performed in two patients with varus alignment and mild joint space narrowing in the medial compartment. A medial opening-wedge technique was utilized with staples for fixation as has been previously reported [22, 23]. Finally, a lateral extra-articular reconstruction was added to the intra-articular procedure in four patients, including the three in whom failure was attributed to recurrent trauma. The technique utilized a gracilis graft looped through the femoral bone block of the intra-articular graft, passed under the lateral collateral ligament, and secured into Gerdy's tubercle [17].

Rehabilitation and follow-up

Postoperative rehabilitation was determined by the associated procedures. Patients undergoing isolated ACL reconstruction with or without the addition of a lateral extra-articular repair

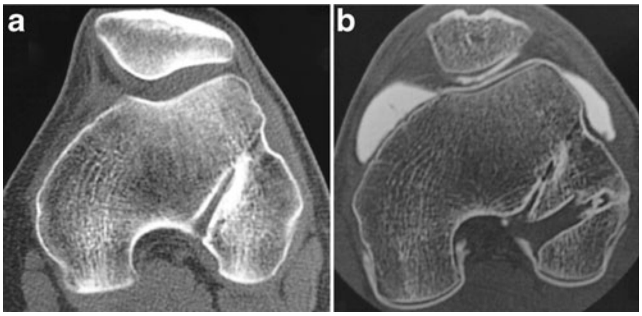

Fig. 1 Axial computed tomography (CT) images of a left knee of a patient undergoing re-revision ACL reconstruction. **a** In a preoperative CT, a vertical femoral tunnel is visible from the prior revision ACL reconstruction. **b** A postoperative CT reveals the prior vertical femoral tunnel as well as a new femoral tunnel in an anatomic position lower of the wall of the lateral femoral condyle as placed by the outside-in drilling technique

were allowed immediate full range of motion and weight-bearing with a brace. Patients undergoing a concurrent osteotomy were allowed full range of motion but limited to touch-down weight-bearing for 8 weeks postoperative. Patients undergoing posteromedial reefing or posterolateral corner reconstruction were braced in 10° of flexion to avoid any hyperextension and limited to partial weight-bearing for 6 weeks.

Data were collected for this retrospective study by an independent orthopedic surgeon who contacted the patients and performed a physical examination according to the IKDC [24]. Radiographic evaluation included weight-bearing AP, lateral, and Schuss views of the knee, Lachman stress views to assess stability, and full leg length views to assess alignment. Additionally, patients completed a subjective IKDC evaluation form [25]. Patients were also asked if they were satisfied with the results of the procedure.

Statistics

Descriptive statistics including mean and standard deviation were obtained for continuous data. Preoperative and post-operative anterior tibial translation on stress radiographs were compared with a paired *t* test. Preoperative and post-operative physical examination findings including Lachman and pivot shift as well as overall IKDC scores were compared using Fisher's exact tests. An alpha of less than 0.05 was considered to be statistically significant.

Results

The previous ACL graft was ruptured in four cases, distended and nonfunctional in two cases, and absent in two cases at the time of re-revision surgery. Meniscal (seven patients) or cartilage (five patients) damage was present in all patients at the time of re-revision ACL reconstruction. The cumulative incidence of meniscal pathology was noted to increase from primary ACL reconstruction to revision to re-revision (Fig. 2).

Seven patients (87.5 %) were available for follow-up at a mean of 4.4±2.3 years postoperative (range 1 to 6.8 years). Knee stability on physical examination improved with surgery (Table 2). Clinical Lachman examination improved in six patients and was unchanged in one patient (p=0.013). The pivot shift examination improved in five patients was unchanged in one patient and worsened in one patient (p=0.33). Two graft failures were diagnosed based on physical examination findings of a soft endpoint on Lachman examination (one patient) or a pivot shift of at least grade 2 (one patient).

Overall IKDC score improved in all patients (Table 1). The postoperative subjective IKDC score was 56.9±16.9. Five of seven patients were satisfied with the result of their revision ACL reconstruction. The two patients dissatisfied with their results included one patient with a persistent grade 2 pivot shift (classified as a graft failure) and another patient with a stable knee subjectively and on physical examination that reported persistent pain in the knee. Postoperative activity level included walking and activities of daily living in five patients, straight-line jogging and running in one patient, and moderate cutting sports such as tennis in one patient.

Anterior tibial translation measured on stress radiographs relative to the contralateral side decreased in all patients. The mean value decreased from 8.3±2.9 to 3.0±2.6 mm (p=0.0025). Radiographs revealed evidence of osteoarthritis (IKDC B [24]) in the two patients that underwent HTO that was unchanged from preoperative radiographs. No evidence of degenerative disease was noted in the other five patients.

The one patient who was lost to follow-up was last seen 5 months after surgery. At that time his Lachman and pivot shift

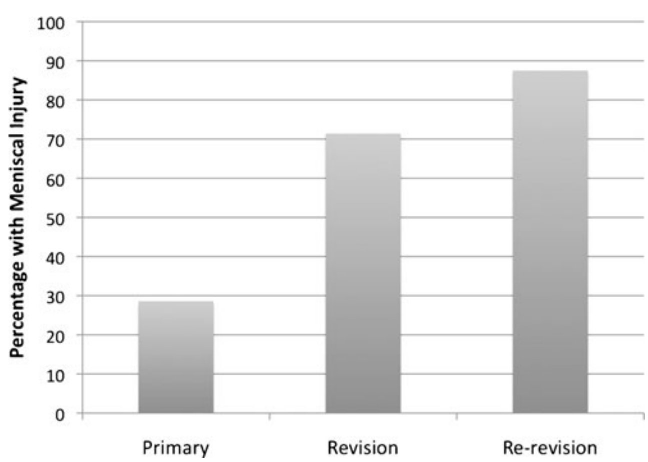

Fig. 2 Graph showing the cumulative incidence of meniscal pathology in the study patients when they underwent primary, revision, and re-revision ACL reconstruction. A clear increase in meniscal damage is noted

Table 2 Pre- and postoperative stability

	Preoperative	Postoperative	Significance
Lachman	Firm, 0 Delayed, 1 Soft, 6	Firm, 5 Delayed, 1 Soft ,1	p=0.013
Pivot shift	None, 1 Glide, 3 Clunk, 1 Gross, 2	None, 4 Glide, 2 Clunk, 1 Gross, 0	p=0.33
Radiographic Lachman (side to side difference)	8.5±3.1 mm	3.0±2.8 mm	p=0.0025
Overall IKDC Score	A, 0 B, 1 C, 4 D, 2	A, 2 B, 4 C, 1 D, 0	p=0.046

were improved one grade from preoperative. No patient-reported outcome scores or radiographic findings are available.

Discussion

The key finding of this study is that re-revision ACL reconstruction decreases anterior tibial translation and improves overall IKDC knee scores when the reason for failure of the first revision is identified and addressed. Re-revision ACL reconstruction has been described as a salvage procedure [26] and although our data confirm poorer outcomes than with primary ACL reconstruction, we noted significant improvement in stability in the majority of patients.

We believe several key points contribute to successful outcomes. Most importantly, to avoid recurrent failure it is important that one not simply repeat the procedure performed in the first and second ACL reconstructions—the reasons for prior failure must be determined and addressed. Primarily, one must address any associated instability and tunnel malpositioning. Addressing all associated factors contributing to instability (posterolateral or posteromedial instability as well as increased tibial slope) is especially important in cases with associated meniscectomy to compensate for the loss of this key secondary restraint to anterior tibial translation [27]. In cases in which failure is attributed to traumatic re-injury, we have chosen to add an extra-articular tenodesis because this procedure has been shown to decrease stress on the intra-articular graft [28, 29] as well as efficiently control the pivot shift by decreasing anterior tibial translation of the lateral tibial plateau [30, 31].

Second, grafts must be anatomically positioned and securely fixed. The presence of tunnels and bony changes from prior surgeries complicates positioning. Tunnel positioning based on landmarks that are present in all cases, such as the method based on the posterior synovial reflection and anatomy of the lateral femoral condyle described by Kaseta et al. [32], is more useful in these cases than methods based on the lateral intercondylar ridge [33]. Fixation can be a challenge in re-revision cases due to poor bone quality and the presence of prior tunnels. We have utilized a femoral fixation technique that relies on cortical bone of the anterolateral femoral metaphysis rather than cancellous bone and the often-compromised cortical bone of the notch [16–18]. This secure, reproducible fixation that allows precise control of the femoral tunnel aperture may have significantly aided our results.

Third, patient expectations must be appropriate. The relatively low postoperative activity levels noted in this study demonstrate that although the majority of the patients were satisfied with the outcomes, they did not often return to cutting and pivoting sports and other high-demand activities.

There were only two patients who were dissatisfied with their results. These included the one patient with a persistent pivot shift greater than a glide. Interestingly, this patient was also the only patient who reported subjective feelings instability postoperatively. We believe an uncontrolled pivot shift to be more symptomatic than increased sagittal plane translation in most patients. The other patient who was dissatisfied with his result had a primary complaint of pain in addition to instability prior to his re-revision surgery. Surgery resulted improved stability but persistent pain and dissatisfaction.

Only one previous study has analyzed the results of re-revision ACL reconstruction. In 2009, Wegrzyn et al. reported on the 3-year results of ten patients undergoing re-revision ACL reconstruction [26]. They noted similar percentages of patients with meniscal pathology (90%) and articular cartilage pathology (70%) to those noted in our study. The reasons for prior graft failure were quite different between the two series. In the current series, 37.5% of failures attributed to recurrent trauma and 25% were attributed to tunnel malposition. In the series of Wegrzyn et al., 60% were attributed to recurrent trauma and 40% to tunnel malposition. Wegrzyn et al. did not employ additional procedures in association with intra-articular ACL reconstruction, in part due to the etiology of the previous graft failures in their series. Both studies noted similar decreases in anterior tibial translation. Overall IKDC classifications of A or B were noted in seven of ten patients in their series and six of seven patients in the current series. Similar decreases in patient activity level were noted in the series of Wegrzyn et al. with 80% of the patients either decreases their level or sports activity or quitting sports altogether. This consistent finding in both studies underscores the need for patients to modify their activity level following multiple ACL injuries.

This study has several weaknesses. First, the number of patients included is quite small, reflecting the rarity of re-revision ACL reconstruction. The small numbers in our series leave the study relatively underpowered to detect differences in the pivot shift before and after surgery. The small number of patients also precludes the comparison of outcome scores based on the reason for failure of prior surgeries or the surgical technique at re-revision. Prior work in first-time revision surgery suggests that those with tunnel malposition in prior cases may do better [15]. Unfortunately we lack sufficient numbers to make such comparison. Second, the retrospective nature of the study led to missing data. Particularly useful would have been preoperative subjective IKDC scores for comparison to those obtained postoperatively. It remains unclear if the decreased laxity achieved in this population translates to improved patient-reported outcomes. We did note satisfaction with the procedure in five of seven patients, but such assessments do not represent a validated patient-reported outcome tool. Finally, the follow-up period is too short to allow meaningful analysis of the progression of degenerative disease in these patients.

Conclusion

Re-revision ACL reconstruction including identification and treatment of reasons for prior failure results in decreased knee laxity and improved IKDC scores. However, improvements were not seen in all patients and all results lagged behind those reported in primary ACL reconstruction.

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