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ORIGINAL STUDY

Results of revision anterior cruciate ligament reconstruction using a transportal technique

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Background : **As the number of anterior cruciate ligament (ACL) injuries and primary ACL reconstruction surgeries increase, the absolute number of re-ruptures or failures has also subsequently increased. In our study, we look at the causes of failure in the primary surgery and also report the clinical and functional outcomes in our series of patients undergoing revision surgery.**

Materials and Methods : **We performed a retrospective review of all revision ACL reconstructions performed by the senior author over a 3-year period using a single-stage transportal technique. Causes of failure were elucidated through clinical, radiological and intraoperative assessment. Outcomes of revision surgery were assessed clinically as well as functionally through the use of a variety of subjective knee scores, with a mean follow-up time of 27.5 months (range 12-40).**

Results : **In our series of 13 patients, all primary surgeries were performed originally via a transtibial technique, with a mean time to failure of 26.4 months (range 6-65). Tunnel malposition was identified as the most common cause of failure (61.5%), while purely traumatic causes accounted for 38.5% of cases. New meniscal injuries were identified in 77% of the patients, and cartilage loss in 38.5%. There was a statistically significant improvement in functional outcomes in all patients following revision surgery, and whilst majority (92%) were able to return to sporting activities on a regular basis, only 54% were able to return to their previous level of sports.**

Conclusion : **Tunnel malposition was found to be the most common cause of primary graft failure in our series of patients undergoing revision ACL reconstruction. Concomitant meniscal and cartilage pathologies were also common intraoperative findings. Improved knee stability and functional outcomes can be expected following revision surgery, and majority will be able to return to some form of sporting activity, albeit at lower levels than before for some patients.**

Keywords : anterior cruciate ligament (ACL) ; graft failure ; revision ; outcomes.

INTRODUCTION

ACL reconstruction remains one of the most commonly performed orthopaedic procedures (*13*). With the increasing number of ACL injuries and primary ACL reconstructions, the absolute number of re-ruptures and failures requiring a revision procedure is similarly on the rise (*7*). Although the quality of surgical techniques and fixation materials has improved over the years, there remains a failure incidence of 20-25% after ACL reconstruction that requires further surgical treatment (*7,16*). ACL graft

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failures can occur for a variety of reasons, leading to loss of secondary restraints with subsequent early cartilage wear (*1*). Graft failure can often be attributed to either technical, biological or mechanical factors and several studies have suggested that technical causes, such as inappropriate positioning of the tibial or femoral tunnels, inadequate notchplasty, or inadequate graft fixation, remain amongst the most important causes of primary graft failure (*5*).

Despite the above, revision ACL surgery still remains a relatively uncommon procedure, accounting for less than 10% of all knee ligament reconstructions (*11*). As such, the number of studies with high level of evidence remains low due to the relative paucity of studies with sizeable study populations, and majority of knowledge regarding outcomes of revision surgery has been gleaned through data from small case series. However, with the establishment of national registries in Scandinavia, coupled with the recent multicenter prospective cohort studies looking at both primary and revision ACL reconstruction surgeries in the Multicenter Orthopedic Outcome Network (MOON) and Multicenter ACL Revision Study (MARS) groups, we are beginning to understand more about the epidemiology and outcomes of patients undergoing revision surgery (*6*,*17*,*18*). These studies provide more reliable data and are likely to provide a more realistic outcome of revision ACL reconstruction surgery.

The general belief amongst most orthopaedic surgeons is that revision surgery is likely to portend a poorer outcome in contrast to that following a primary procedure. This is based on both anecdotal experience as well as outcomes reported in the literature, which have consistently reported inferior results of revision surgery as opposed to primary ACL reconstruction (*5*,*10*). This has also been the consensus view of the current group of surgeons involved in the MARS trial, an important consideration in an era where patients often hold the expectations that should a revision surgery be necessary, the results will be similar to that of the primary reconstruction.

This study is a retrospective case series looking at the epidemiology and outcomes of revision ACL reconstruction performed within our institution. The purposes of our study are : (1) to identify causes of failure in the primary surgery, and (2) to evaluate outcomes of revision ACL reconstruction in our centre.

MATERIALS AND METHODS

We looked at all patients who had a revision ACL surgery that was performed by the senior author between January 2010 and December 2012. 13 patients were identified and included in our study population. This study was approved by the relevant Ethics Committee Board.

Causes of failure of the primary surgery were elucidated through a combination of clinical, radiological and intraoperative assessment. Clinical assessment was done by analyzing clinical data in the individual patient's case notes. Preoperative radiographs and magnetic resonance imaging (MRI) scans were also evaluated to look for possible causes of graft failure. Significant intraoperative findings were noted by looking through the operative pictures as well as documentation in the operative notes. From these parameters, we were able to derive the likely cause or causes of graft failure in the primary surgery.

All patients in our study population underwent a single-stage revision surgery that was performed via a transportal technique. Single-bundle anatomical reconstruction was performed through the creation of new femoral and tibial tunnels. As far as possible, the old fixation devices and implants were left in-situ. For the femoral fixation, the Endobutton system (Smith-Nephew Endoscopy, Andover, MA, USA) was used, with Endobutton CL loop® used in 8 cases, and Endobutton Direct® used in 5 cases. Tibial fixation was performed using interference screw, with 7 patients requiring additional augmentation with staple fixation and 5 patients requiring additional augmentation with a tibia post. Contralateral hamstring tendons were the graft of choice in 6 cases, with allografts being used in the remaining 7 cases. For the allograft, looped peroneus longus tendon was used in 3 cases, tibialis anterior tendon was used in 3 cases, and tibialis posterior tendon was used in the remaining case. Size of the grafts ranged from 7.0 to 8.5 mm in the contralateral hamstring group, and from 8.0 to 9.0 mm in the allograft group. 1 patient also required a posterolateral corner reconstruction that was performed using the Larson's technique (*15*).

Outcomes of revision ACL surgery in our series of patients were assessed using both clinical and functional outcomes. We looked at the range of motions of the knee joint as well as the anterior drawer and Lachman's tests to quantify knee stability clinically. This was performed by the senior author during the final follow-up with the

individual patient. Functional outcomes were assessed through the use of various subjective knee scores such as the International Knee Documentation Committee Score (IKDC) (*8*), the Knee Injury and Osteoarthritis Outcome Score (KOOS) (*4*), and the Lysholm Score (*12*). All patients completed the forms at the final follow-up assessment. IKDC scores were tabulated using the AOSSM website and compared to age and gender-based norms (*2*).

RESULTS

There were 12 male and 1 female patients in our study population. Of these, surgery involved the left knee in 9 patients, and the right knee in 4 patients. The mean age of the patients at the time of primary surgery was 24.7 years (range 17-48) and 27.7 years (range 20-55) at the time of the revision surgery. Following the primary surgery, all patients had been able to return to IKDC level I or II sporting activities, which include sports like basketball, soccer and netball, following a period of rehabilitation.

In our series of patients, the mean time to failure from the primary surgery was 26.4 months (range 6-65), and the mean time taken to undergo the revision surgery was 36.0 months (range 10-80) (Table I). The mean time from the point of re-injury or graft rupture to revision surgery was 9.6 months (range 2-27) in our institution. The mean follow-up time of our patients following revision surgery was 27.5 months (range 12-40).

All primary surgery had been performed via a transtibial technique, and the graft used in the original surgery was the ipsilateral hamstring tendons in all patients. For the femoral side, fixation was achieved through the use of the Transfix® (Arthrex, CA, USA) in 4 cases, the Endobutton® (Smith-Nephew, Andover, MA, USA) in 4 cases, the ACF® (Orthomed S.A.S, St Jeanette, France) in 3 cases, and the Rigidfix® (Depuy-Mitek, Raynham, Massachusetts, USA), in the remaining 2 cases. For the tibial side, fixation was achieved using the corresponding tibia screw of the above implants, and none had augmentation with additional staples or tibia posts.

In our series, all patients had a history of trauma prior to the re-injury, with soccer injuries accounting for about 61.5% (n = 8/13) of all graft ruptures. Tunnel malposition (Figs. 1a, 1b and 2) was identified as the primary contributor to failure in 61.5% (n = 8/13) of cases, with problems in femoral tunnel placement occurring in 5 cases, and problems with tibia tunnel placement in 3 cases. Approximately

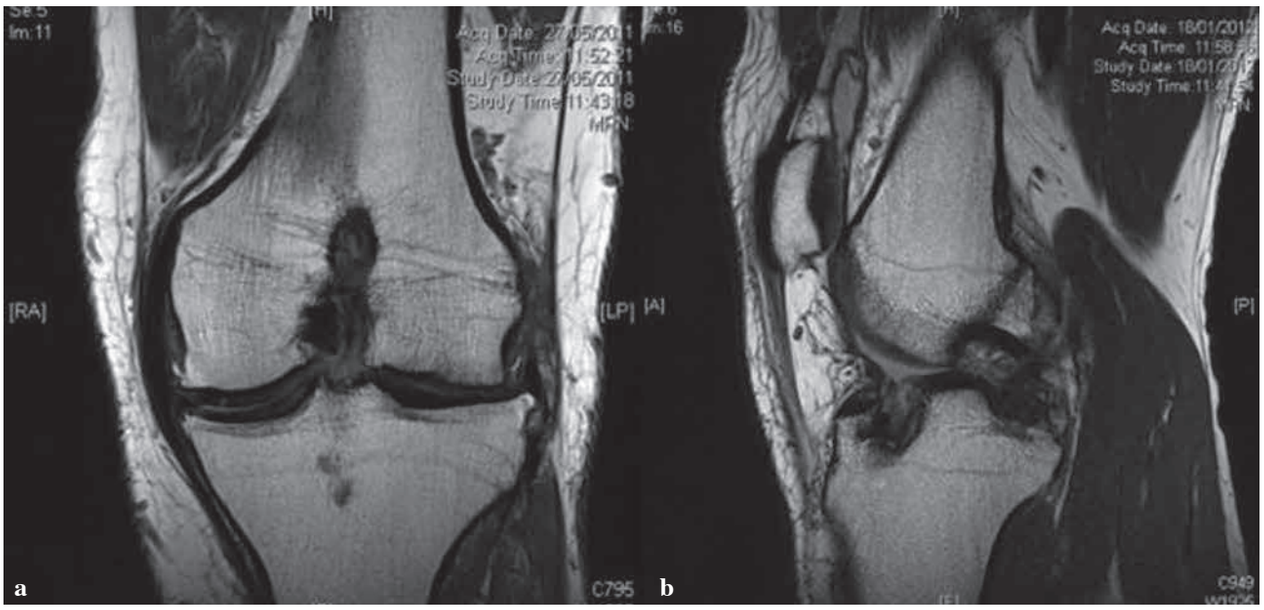


Fig. 1a and 1b. — MRI scans (T1-weighted) showing femoral and tibial tunnel malposition

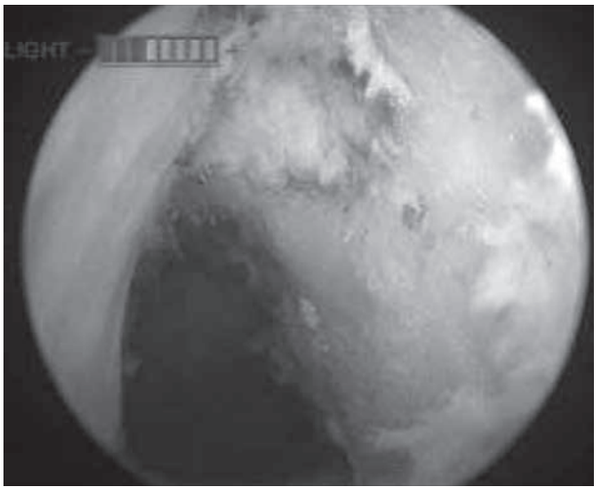


Fig. 2. — Intraoperative arthroscopic picture in a patient revealing too vertical femoral tunnel position.

one third of all failures (38.5%, $n = 5/13$) were believed to be due to purely traumatic re-injuries.

During the revision procedure, concomitant injuries involving the menisci and cartilage were common intraoperative findings. New menisci injuries were identified in 10 patients (77%), of which 6 involved the lateral meniscus, 1 involved the medial meniscus, and 3 involved both menisci. These were tears that had not been documented during the primary arthroscopic reconstruction or noted on previous MRI scans. 10 tears were deemed not suitable for repair, and were treated with partial meniscectomies. 3 tears were treated with an all-inside repair technique. Partial thickness cartilage injuries were seen in 5 patients (38.5%), and all were treated with debridement and chondroplasty of any unstable chondral flaps. A concomitant posterolateral corner injury was also identified in 1 patient (7.7%), which necessitated a posterolateral corner reconstruction in the same setting.

On follow-up, recovery of one patient with allograft reconstruction was complicated by methicillin-susceptible Staphylococcus Aureus (MSSA) septic arthritis of the knee. This developed approximately 3 weeks after the revision procedure and was treated successfully with arthroscopic synovectomy and washout with graft retention and a course of intravenous antibiotics. The patient subsequently recovered well and was able to return to play basketball at his pre-injury level.

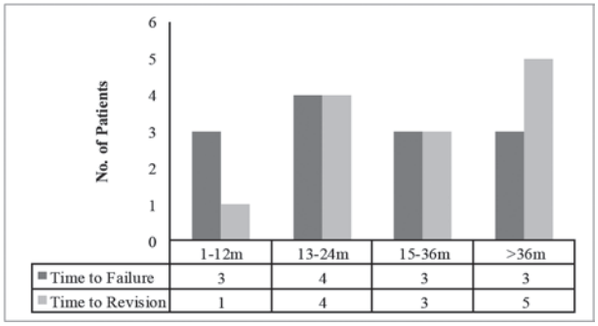
On clinical assessment, the average range of motion at final follow-up was 129 degrees (range 110-140). Anterior drawer and Lachman's tests were normal in 8 patients, and mild laxity (< 5 mm translation) with firm end-points were noted in the remaining 5 patients.

The mean preoperative IKDC score was 47.9 (range 19.5-73.6, SD 15.2) and the mean postoperative IKDC score was 78.3 (range 49.4-93.1, SD 12.9) (Table I). The mean improvement of IKDC scores following revision surgery was 30.4% ($p < 0.001$). The mean overall preoperative KOOS score was 53.1 (SD 15.1), with an improvement to 80.1 (SD 9.5) following revision surgery. On further sub-analysis, symptom score improved from 57.1 to 79.7, pain score improved from 70.1 to 90.6, ADL score improved from 79.2 to 96.6, ability to participate to sports improved from 35.0 to 71.9 and quality of life (QOL) score improved from 26.4 to 61.5 (Table III). All results were found to be statistically significant. Using the Lysholm score, mean preoperative score was 56.8 (range 28-81, SD 14.2) and mean postoperative score was 86.0 (range 66-95, SD 8.3) (Table IV). There was a mean improvement of 29.2 points ($p < 0.001$).

In this series, 92% of patients were able to return to some form of sporting activity on a regular basis. However, only 54% were able to return to their pre-injury level of sporting activity participation.

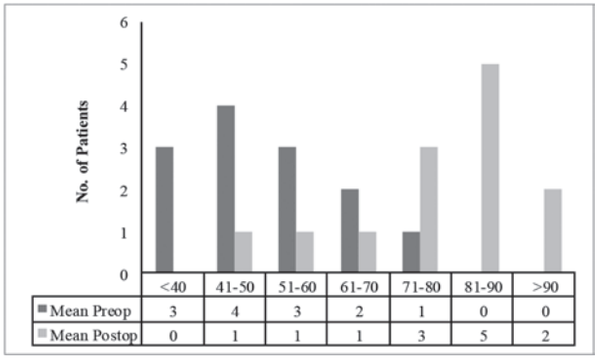
Following revision surgery, majority had clinical improvement in knee stability, with 61.5% (n = 8/13) having normal anterior drawer and Lachman's tests. The remaining 38.5% (n = 5/13) displayed mild laxity with some anterior translation of the tibio-femoral joint, but all had firm end-points following revision surgery. In this series, all patients showed improvement in functional outcomes following revision surgery. This was regardless of the type of subjective knee scoring system used and all results were found to be statistically significant with a mean follow-up time of 27.5 months following revision surgery. On further subgroup analysis using the KOOS score, greatest patient satisfaction and improvements following revision surgery was found in their ability to return to sports (50.1% im-

Table I. — Mean time to graft failure and revision surgery



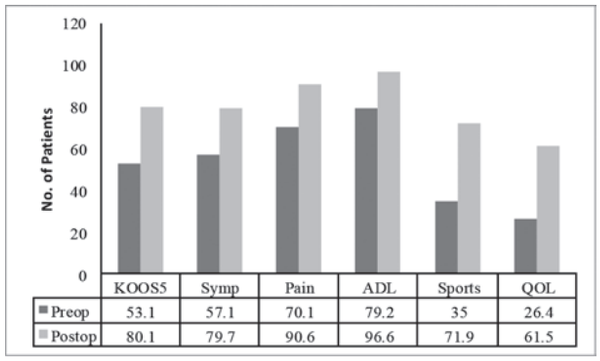
	1-12m	13-24m	15-36m	>36m
Time to Failure	3	4	3	3
Time to Revision	1	4	3	5

Table II. — Mean pre- and postoperative IKDC scores



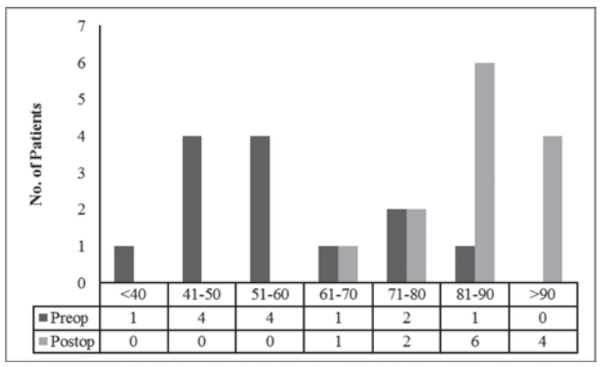
	<40	41-50	51-60	61-70	71-80	81-90	>90
Mean Preop	3	4	3	2	1	0	0
Mean Postop	0	1	1	1	3	5	2

Table III. — Mean pre- and postoperative KOOS scores



	KOOS5	Symp	Pain	ADL	Sports	QOL
Preop	53.1	57.1	70.1	79.2	35	26.4
Postop	80.1	79.7	90.6	96.6	71.9	61.5

Table IV. — Mean pre- and postoperative Lysholm scores



	<40	41-50	51-60	61-70	71-80	81-90	>90
Preop	1	4	4	1	2	1	0
Postop	0	0	0	1	2	6	4

provement), as well as in their quality of life (57% improvement). In contrast to other studies, which report an incidence of 50-60% of patients being able to return to sports following revision surgery (*3*), majority of patients in our study (92%, n = 12/13) were able to return to some form of sporting activities on a regular basis. However, only 54% (n = 7/13) were able to return to the level of sporting participation that they had been accustomed to prior to the graft failure.

DISCUSSION

Whilst the proportion of patients undergoing a revision ACL procedure remains relatively small, the absolute numbers are on the upward trend due to the increasing number of ACL injuries as well as patients undergoing primary ACL reconstruction (*7*). In tandem with the demographics of patients in other studies, those in our study population were of a younger age group, with a mean age at time of revision surgery of 27.7 years. These patients tend to be more active and mobile, and often hold the expectations of being able to return to their pre-injury level of functioning and sports participation. Whilst majority of patients will have improvement in clinical and functional outcomes following revision surgery, and majority will be able to return to participate in sporting activities on a regular basis, approximately half will not be able to reach the same level of sporting participation that they were once accustomed to prior to graft failure. This is important during the pre-revision counselling to tailor the expectations of the patients, especially when they anticipate the outcomes to be similar to that after the primary surgery.

Graft failure can be due to technical, biological or mechanical (traumatic) factors, or a combination of the above. Studies have shown that technical shortcomings are the most common cause of failure in those coming for revision surgery. In one series, technical failures, such as nonanatomical tunnel

placement, inadequate notchplasty, or insufficient graft material, were implicated in 77% of the revision cases (*10*). In our series, technical factors were also found to be the primary contributor of graft failure, with tunnel malposition accounting for 61.5% ($n = 8/13$) of failures. All cases invariably were performed via a transtibial technique during the primary surgery, resulting in tunnel positions which were more vertically placed. In this series, none of the index surgeries had been performed by the senior author as he routinely employs a transportal, rather than a transtibial technique in all of his cases. All graft failures in our series also had solitary graft fixation on the tibial side without additional augmentation, raising the question of whether it may be prudent to consider the use of supplementary fixation in future to minimize risk of graft failure. The remaining one-third of failures can be attributed to purely traumatic factors, not dissimilar to the figures in the Western population, such as that in the MARS cohort (*18*).

Due to loss of knee stability afforded by an intact cruciate ligament, concomitant injuries involving the menisci and cartilage were also common intraoperative findings. New meniscal injuries were identified in 77% ($n = 10/13$), and cartilage loss in 38.5% ($n = 5/13$). This is important as these injuries may affect the long-term outcomes and prognosis of these patients, as well as have a significant implication on the post-operative rehabilitation and protocol.

Whilst the long-term outcomes of patients undergoing revision ACL surgery remain under investigation, it is the senior author's personal preference to employ a transportal technique in this challenging procedure. This will allow for a more anatomical placement of the femoral tunnels (*14*), reducing the risk of graft impingement and minimizing excessive graft tension. Supplementary augmentation on the tibial side is also routinely performed where possible to increase the fixation strength of the graft (*9*).

This study is essentially one which looks at our experience with regards to the assessment of patients presenting with ACL graft failures, and their subsequent management and follow-up. This study is not without its limitations, chief amongst them the retrospective case series design of this study. We also have a relatively small sample size of 13 patients, and a relatively short follow-up period, with a mean follow-up period of 27.5 months after revision surgery. Also, whilst we have attempted to mitigate the subjective nature of clinical assessment of knee stability by having all assessments performed by the senior author himself, it would perhaps have been even more accurate with the use of an objective instrument of measurement, such as the KT-1000 arthrometer, or through an unbiased clinical assessment of a blinded external assessor.

In conclusion, revision ACL surgery remains a relatively uncommon but challenging operation. Tunnel malposition was found to be the most common cause of graft failure in our series of patients. Improved knee stability and functional outcomes can be expected following revision surgery, and majority will be able to return to some form of sporting activities, albeit some at lower levels than pre-injury. Patients who undergo revision ACL surgery should be counselled as to the expected outcome and cautioned that this procedure probably represents a salvage procedure and may not allow them to return to their desired or expected levels of function. Concomitant meniscal and cartilage pathologies are also common intraoperative findings, and may affect the long-term prognosis and post-operative rehabilitation of these patients.

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