A prospective study to assess the outcomes of revision anterior cruciate ligament reconstruction

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Abstract

Purpose Continuously increasing numbers of primary anterior cruciate ligament (ACL) reconstructions invites a parallel increase in graft failures and need for revision ACL reconstruction surgery. High failure rates has previously stigmatised the revision surgery. We performed this study using multiple outcome measures together with clinical examination to offer a full assessment of the outcomes of this procedure.

Methods Twenty patients, with mean age of 29.4 years (17–50 years), were included in this study prior to their revision ACL reconstruction surgery. All patients were followed prospectively collecting the Knee injury and Osteoarthritis Outcome (KOOS), International Knee Documentation Committee (IKDC) and Tegner-Lysholm scores pre- and post-operatively together with clinical assessment of the antero-posterior knee laxity.

Results After a mean follow up interval of 30 months (16–60 months) significant post-operative improvement of IKDC, Tegner-Lysholm scores and knee antero-posterior laxity together with the Symptoms, Activities of Daily Living (ADL) and Quality of Life (QOL) components of the KOOS score was noticed ($P<0.05$). However, there was no similar improvement in pain and sports components of the KOOS score ($P>0.05$). There was no difference in the outcomes of different graft types.

Conclusion Good outcomes of revision ACL reconstruction surgery are achievable. The use of different graft types did not affect the outcome of the procedure. Most of the patients opted to less aggressive sports participation after the revision procedure.

Keywords Anterior cruciate ligament · ACL · Reconstruction · Revision · Knee · Ligament

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Introduction

ACL is the most commonly injured knee ligament with a reported incidence of 30/100,000 people in the UK [1] rising up to 3.7 % per person among professional basketball and soccer players [2]. Injury to the ACL can result in recurring knee instability with a higher incidence of post-traumatic arthrosis [3]. ACL reconstruction has become a common procedure with satisfactory long-term outcomes [4]. However, despite recent advances in the ACL reconstruction, re-rupture remains a problem with the incidence of re-rupture reported to vary between 4.3 and 23.33 % in the current literature [5, 6].

Several risk factors have been attributed to the failure of primary ACL reconstruction which include age of the patient, technical errors at the time of primary reconstruction, traumatic reinjuries, infection and spontaneous biological failure of graft incorporation [7, 8]. Literature is still lacking an

evidence-based proof of the best graft for primary ACL reconstruction [9]. Poor outcomes of revision ACL reconstruction mandate the optimization of conditions at time of the primary ACL reconstruction surgery [10, 11].

We conducted a prospective study to assess various subjective and objective outcomes and the complications of revision ACL reconstruction surgery performed in our unit, particularly with reference to the type of graft used for revision reconstruction.

Patients and methods

We prospectively analysed all the patients who underwent a revision ACL reconstruction by the senior author over a nine-year period from 2001–2010 in our unit. All patients referred with failed ACL reconstruction and who had a revision ACL reconstruction were included in the study. In order to investigate a homogenous cohort of single-stage revision ACL reconstruction patients, we excluded patients who required a two-stage revision due to significant bone tunnel lysis and bone grafting of the tunnels in the first stage. Patients with short follow-up intervals (less than 12 months) and who failed to attend the follow-up visits were also excluded.

The senior author clinically assessed all the patients with a failed ACL reconstruction. As a routine all the patients had standard weight-bearing anteroposterior and lateral knee radiographs followed by computerised tomographic (CT) scanning and magnetic resonance imaging (MRI) of the involved knee. Once diagnosed all the patients underwent a knee rehabilitation programme under the supervision of a specialised knee physiotherapist. Surgery was only offered once the conservative measures failed. All the revision procedures were performed by the senior author.

After careful assessment of the patient's knee for mechanism of injury, exclusion of infection, associated laxities, alignment issues and availability of alternate graft choices a plan was made and the patients counselled as to the most likely graft choice. Allograft was reserved for cases where there were no suitable autograft choices. Hamstring quad stranded grafts (QH) were used if possible due to less donor site morbidity, bone-patellar-tendon-bone (BPTB) if the patients declined contralateral hamstring harvest or if there was a minor degree of tunnel widening and quadriceps tendon if the patient had a job or sport that required kneeling ability and had had previous hamstring harvest or had tunnel widening over 11-mm diameter. The tibial tunnel would be made by overboring of a previous well-placed tunnel if possible, or by converging into the previous joint orifice if it was appropriately placed but the previous tunnel orientation was an issue or if it was possible to avoid asymptomatic previous hardware removal by doing so.

Femoral socket placement was at 10:30/1:30 just anterior to the over-the-top position, achieved either by using the tibial tunnel or medial portal for guide wire insertion, using whichever had not been employed in the previous technique, if the entrance to the socket was appropriately placed. Revision was easiest if the previous socket's positioning was very different to that planned in the revision, particularly if metalwork would not compromise the new graft or if the previous tunnel was well placed and a wider bore graft allowed overboring, or a traumatic event had led to failure of a well-positioned graft and a similar diameter graft remained available for the revision by harvesting from the contralateral knee. The most difficult revisions were for the cases where the previous socket compromised the orifice position available for revision socket placement and a divergent socket orientation would not allow a satisfactory new bone tunnel, or if blowout was an issue when suspensory fixation would be utilised.

In all cases presented in this series, rehabilitation was possible using the standard postoperative protocols employed in primary reconstructions using the graft employed in the revision procedure.

The patients were reviewed pre-operatively and then post-operatively at two weeks, six weeks, three months, six months, 12 months and then on a yearly basis. All the patients were reviewed by an independent observer. We used comprehensive subjective and objective measures which included the IKDC [12], KOOS [13] and Tegner-Lysholm scores [14]. Clinically the antero-posterior knee laxity was assessed by using the Rolimeter (Aircast, USA®) [15] at 30° and 90° of knee flexion [16]. A mean of three readings, at 30° and 90° of knee flexion, was used.

Two-tailed Student *t*-test was employed for statistical evaluation (statistical pack SPSS 11.0), and a *p*-value of ≤ 0.05 was considered significant.

Results

Twenty-four patients underwent revision ACL reconstruction during the study period. Of these, four patients were excluded. Two patients had a short post-operative follow-up (less than 12 months post-operatively), one patient migrated and one patient required a two-stage revision due to significant preceding tunnel lysis. Thus there were 20 patients (19 males, one female) with mean age of 29.4 years (range 17–50 years, SD 8.75) available for follow-up. Of these 20 patients, 11 patients were secondary referrals while nine were failure of the primary ACL reconstructions performed by the senior author. The rate of failure of the primary ACL reconstruction in the cohort of patients operated by the senior author during the study period was 2.25 % (10/442).

Of these nine patients, two patients also had associated medial meniscus tears and one patient had associated lateral

meniscus tear. Of the 11 secondary referrals two patients presented with a failed revision procedure and thus underwent a repeat revision procedure. The mean post-operative follow-up for all the patients was 30 ± 14 months.

Of the 18 patients who underwent a revision ACL reconstruction nine patients had ipsilateral BPTB grafts, seven had QH autografts and two had synthetic (one carbon fibre and one Dacron) grafts. The two failed revision cases had contralateral hamstring tendon (one patient) and ipsilateral quadriceps tendon (one patient) autografts (Fig. 1). Associated injuries with failed ACL grafts were posterolateral corner (PLC) injury (two patients; both were grade 1 PLC injury with intact PCL), lateral meniscus tears (three patients), medial meniscus tear (two patients), failed repair of medial meniscus tear in a previous surgery (one patient) and a lateral tibial plateau articular cartilage flap tear (one patient) (Table 1).

Eleven patients (55 %) ruptured their primary grafts by mechanical trauma (seven sports injuries: five rugby and two football) while improper tunnel placement at the time of the primary procedure was the cause of failure in four patients (20 %) and five patients (25 %) had a spontaneous biological failure of their grafts.

The grafts used for revision were ipsilateral QH graft (ten patients), contralateral QH graft (four patients), ipsilateral BPTB graft (two patients), contralateral BPTB (one patient), ipsilateral quadriceps tendon graft (two patients) and tendo-achillis allograft (one patient) (Table 2).

As shown in Table 3 mean pre-operative Lysholm score was 59.7 ± 16.36 , which significantly increased to 87.5 ± 13.53 at the last follow up ($p < 0.05$). Similarly, mean pre-operative IKDC scores (51.2 ± 17.63) significantly improved postoperatively (75.33 ± 16.32) ($p < 0.05$). In KOOS scores, we noticed significant improvement in symptoms (59.36 ± 13.4 to 78.68 ± 12.7), ADL (78.12 ± 9.81 to 94.67 ± 11.6) and QOL scores (35.93 ± 12.4 to 58.75 ± 9.4) (p -value 0.015, 0.021 and 0.00, respectively). However no such improvement was noted in the pain (76.11 ± 11.2 to 86.59 ± 9.7) and

Table 1 Associated injuries with failed ACL graft at time of referral

Associated injuries at time of referral	Number of patients
Lateral meniscus	3
Medial meniscus	2
Posterolateral corner	2
Failed medial meniscus repair	1
Lateral tibial plateau articular cartilage flap tear	1

sports components (63.88 ± 12.2 to 75.75 ± 13.2) (p -value 0.14 and 0.13, respectively).

Assessment of the AP laxity by the Rolimeter showed significant improvement postoperatively at 30° knee flexion but not in the 90° knee flexion at the final follow up (p -value 0.00 and 0.69, respectively). However, there was no significant difference in the AP laxity between both knees (operated and contralateral knee of the same patient) postoperatively at both 30° and 90° of knee flexion (p -value 0.29 and 0.88, respectively).

In terms of complications one patient developed superficial wound infection which responded to antibiotics, one patient reported spontaneous biological graft failure which required a repeat revision procedure one year after the revision procedure and two patients required posterolateral corner reconstruction six months following the index procedure. One patient developed symptomatic osteoarthritis of the operated knee for which the patient underwent microfracture and removal of metal-ware at three years after the index procedure. Due to ongoing pain despite compliance with postoperative rehabilitation in a stable knee, the patients finally had a successful total knee replacement five years after the revision procedure. This resolved the pain with two years follow up.

We did not notice any significant difference in the outcome measures based on the type of graft used for revision ACL reconstruction. Four types of grafts were compared using all outcome scores ($P > 0.05$).

Fig. 1 Types of failed ACL grafts at time of referral for the revision

Table 2 Types of grafts used for the revision procedures

Types of grafts used for revision procedure	Number of patients
Ipsilateral QH	10
Contralateral QH	4
Ipsilateral BPTB	2
Ipsilateral quadriceps tendon	2
Contralateral BPTB	1
Tendo-achillis allograft	1

Discussion

A ruptured ACL predisposes the knee to the development of early onset osteoarthritis due to recurring instability. However, development of knee osteoarthritis following ACL reconstruction is still debatable because of confounding factors like meniscal injuries at the time of initial trauma and time between injury and the index procedure. Ferretti et al. confirmed that reconstruction prevented the development of osteoarthritis in isolated ACL [17]. Several studies have reported satisfactory short and long-term outcomes following ACL reconstruction largely due to advances in the surgical technique of ACL reconstruction [18].

However, despite advances in surgical technique and with increased understanding of the knee patho-mechanics following ACL injury, failure of the reconstructed ACL remains a difficult problem to deal with.

Several factors have been attributed as the cause of failure of primary ACL reconstruction. These include mechanical trauma, poor technique for primary ACL reconstruction, infection and biological failure of graft incorporation. Infection was reported as a cause of graft failure in less than 1 % [19]. Ménétrey et al. defined biologic failure as failure in the completion of the ligamentization process, leading to an atonic, disorganized, and non-viable graft. They identified increased

graft tension, use of nicotine and cocaine and systemic diseases together with graft choice autograft versus allograft as risk factors for biological necrosis [20]. However, inaccurate tunnel placement at time of primary reconstruction always received the greatest attention in literature as it was the only preventable factor. Femoral tunnel malposition has been reported to be more common and problematic than tibial tunnel malposition [21]. Tescholl et al. used the three-dimensionally reconstructed CT images to optimise the femoral tunnel entry point; however, they concluded that this might change between individual patients and according to surgeon's preferences [22].

Outcomes of revision ACL reconstruction procedure have been variably reported in literature using various outcome measures. By and large most of the authors have noted significantly worse outcomes in comparison to primary ACL reconstruction [23, 24]; however, better results have also been reported by some authors in selected patient populations [25]. Poor outcomes have been mainly attributed to higher incidence of osteoarthritic changes with deteriorating quality of life despite having comparable IKDC scores and stability measurements when compared with primary ACL reconstruction [24].

Currently there is significant discrepancy in the literature regarding the appropriate graft material for a revision ACL reconstruction. Ahn et al. reported results of 59 revision ACL reconstructions comparing the double-looped semitendinosus–gracilis autograft, bone–patellar tendon–bone allograft and Achilles allograft and did not record any significant difference between different graft materials [23]. Denti et al. [26] preferred the use of the hamstring tendon autografts in their study and these were also preferred in the Danish registry, most probably because of the familiarity of the technique in both studies [9]. Both were able to demonstrate successful results. Akhtar et al. advocated the use of BPTB [27]. Revision ACL surgery using autografts did not improve the clinical outcomes in patients who underwent previous failed primary synthetic ligament reconstruction. In addition, it did not influence the natural history of knee osteoarthritis started from artificial ligament debris [28].

Single-stage revision ACL reconstruction is the most favoured technique for revision ACL reconstruction. However, a two-stage procedure has been recommended in cases of tunnel widening, limited range of motion or existent hardware in place of following the primary procedure [29]. Coats et al. considered significant tunnel overlap and lysis as the main indication for two-stage revision [30]. Franceschi et al. demonstrated satisfactory results of two-stage revision ACL reconstruction after five years follow up [29]. Shino et al. proposed a new rectangular tunnel technique as a suitable solution attempting to avoid wide or improperly placed bone tunnels at time of the primary surgery [31].

Table 3 Mean pre and post-operative scores and *P*-values

Score	Mean pre-operative score	Mean post-operative score	<i>P</i> -value
IKDC	51.20	75.34	0.00
Lysholm	59.70	87.50	0.00
Rolimeter at 30° knee flexion	15.43	11.57	0.01
Rolimeter at 90° knee flexion	13.50	11.47	0.71
KOOS Symptoms	59.36	78.69	0.01
KOOS Pain	76.11	86.59	0.14
KOOS ADL	78.12	94.67	0.02
KOOS QOL	35.94	58.75	0.00
KOOS Sports	63.88	75.75	0.13

In our series the majority of patients undergoing revision ACL reconstruction had a satisfactory outcome based on various subjective and objective measures with a relatively long-term follow up. We used comprehensive outcome measures which were lacking in the studies reporting on the outcome following revision ACL reconstruction. We found that graft choice did not significantly affect the outcome in any of the outcome scores (Lysholm, IKDC and KOOS) or post-operative AP stability. Although we did not record an improvement in the sports and pain component of the KOOS scores there was a positive trend noted when compared to the pre-operative scores. The limitations of our study include a small patient population. However, for a single-surgeon single-centre prospective study, our numbers are comparable with other published series [32]. In our series the most common presenting cause of primary graft failure was traumatic (11 patients, 55 %) while improper graft positioning at time of primary surgery came as the third cause (four patients, 20 %) following the biological failure of the graft (five patients, 25 %). This may result from the use of a standardised surgical technique and rehabilitation protocol for the primary procedures.

In conclusion our study shows that the revision ACL reconstruction procedure offers improvement in subjective and objective outcomes. Lack of improvement in sports participation was noted in non-professional athletes and patients who downgraded their sports participation opting for non-contact sports. There was no difference in the outcome between graft materials.

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

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