



Tibial slope correction combined with second revision ACLR grants good clinical outcomes and prevents graft rupture at 7–15-year follow-up

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Abstract

Purpose To update previously published outcomes (at 2–8 years) of second revision anterior cruciate ligament reconstruction (ACLR) combined with tibial deflexion osteotomy (TDO), after an interval of 5 more years (at 7–15 years), and monitor evolution of clinical scores and progression of osteoarthritis.

Methods The initial retrospective consecutive series included nine patients that underwent one-stage second revision ACLR with TDO, all of whom were contacted for second follow-up at minimum 7 years. An independent observer collected IKDC-SKF, the Lysholm score, and assessed radiographs for signs of osteoarthritis.

Results Of the nine original patients, seven were assessed at the clinic, one could only be assessed by telephone, and one was lost to follow-up. At final follow-up of 9.9 ± 3.0 years, the eight patients assessed maintained or improved clinical scores, compared to the previous follow-up at 4.0 ± 2.9 years. The mean Lysholm score improved from 73.8 ± 5.8 (65–82) to 84.5 ± 11.9 (59–95), and IKDC improved from 71.6 ± 6.2 (62–79) to 82.9 ± 12.1 (61–98). Of the three patients that had signs of arthritis at the previous follow-up, the stage of osteoarthritis increased in one (from grade 2 to grade 3), remained unchanged in one, and could not be assessed in one.

Conclusion At 7–15 years following second revision ACLR with TDO, patients maintained or improved clinical scores compared to the previous follow-up at 2–8 years, without retears or reoperations. Although eight of the nine knees had meniscectomies or meniscal sutures, osteoarthritis progressed in only one of the six knees that had signs of arthritis at the previous follow-up. These results confirm that TDO can protect the ACL graft from retear, with minimal progression of osteoarthritis and/or risks of meniscal tears, suggesting that correction of excessive tibial slope should be considered when performing ACLR, whether a revision or primary procedure.

Keywords ACLR · Second revision · Tibial deflexion osteotomy · Outcomes

Introduction

The failure rate of revision anterior cruciate ligament reconstruction (ACLR) is reported to reach up to 25% in terms of graft rupture, and up to 82% in terms of objective clinical failure [15]. Recent reviews have also found inferior patient-reported outcomes following revision ACLR compared to primary ACLR [14], though it is important to note that most

clinical studies have limited follow-up of 2 years or less [17, 18].

An excessive posterior tibial slope (PTS) is known to increase risks of ACL tear [6, 23, 25, 28], but studies on recurrent ACL tears continue to overlook PTS as a risk factor [11]. Engler et al. [12] found that patients with second ACLR failure had higher PTS than those with successful second ACLR but did not attempt to address this risk factor during surgery or postoperative rehabilitation. Tibial deflexion osteotomy (TDO) can be performed to correct excessive PTS during revision ACLR, but is technically challenging, with very little published outcomes [2, 7, 8]. Furthermore, the progression of osteoarthritis is a major concern, especially in knees that require meniscal procedures [3, 20].

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The present authors had published the early outcomes (at 2–8 years) of second revision ACLR combined with TDO in nine patients that had $PTS > 12^\circ$ [8], and reported satisfactory results with no retears, suggesting that tibial slope correction protects the reconstructed graft from fatigue failure. The purpose of the present study is to update the outcomes of the same series after 5 more years (at 7–15 years), to determine how clinical scores evolve over time, and to monitor the progression of osteoarthritis. The hypothesis was that the results of the combined procedures would result in no retears and minimal progression of arthritis OA. The findings of this study could confirm that TDO has a long-lasting protective effect on controlling anterior instability in patient with excessive PTS, while stopping the progression of osteoarthritis.

Materials and methods

The initial retrospective consecutive series that was published in 2015 [8] included nine patients that underwent one-stage second revision ACL reconstruction with adjuvant tibial deflexion osteotomy by the senior surgeon between 2006 and 2012. All patients provided informed consent for the use of their data for research, and the study was approved by the ethical board in advance (GCS Ramsay Santé pour l'Enseignement et la Recherche, COS-RGDS-2021-03-008-DEJOUR-D).

Preoperative assessment

All patients were evaluated preoperatively using the International Knee Documentation Committee Subjective Knee Form (IKDC-SKF), the IKDC objective form, and the Lysholm score for clinical evaluation. Radiographic examination included weight-bearing frontal view, sagittal view at 30° flexion, and axial view at 30° flexion. The posterior tibial slope (PTS) was calculated as described by Dejour and Bonnin [10]. The presence of radiographic signs of

osteoarthritis was graded following the classification of Kellgren and Lawrence [21].

Surgical technique

All patients underwent the same surgical technique, which was previously described by Dejour et al. [8]. Autografts were harvested from the ipsilateral leg (quadriceps tendon or hamstring tendon). The femoral tunnel was prepared using an outside-in guide for femoral tunnel placement. For the tibial tunnel, a standard 60° angulation guide was used. Deflexion osteotomy was then performed, aiming for a PTS between 3° and 5° , with conservation of the patellar tendon insertion. When the resected surfaces united, two staples were inserted for fixation, one on either side of the patellar tendon. Corrected slope was confirmed by fluoroscopy after measurement, and then, final fixation was performed. The graft was passed through and fixed with Ligafix interference screw (SBM, Lourdes, France). In the four knees that had high-grade pivot shift, a modified Lemaire extra-articular procedure [9] was performed. For the first 21 days following surgery, weight bearing was not allowed, and for the first 45 days all patients were required to wear an extension brace to prevent from any hyperextension. Following this, patients followed a previously described rehabilitation protocol [8].

Postoperative assessment

The early outcomes (“first follow-up” at minimum 2 years) of this series have been previously published [11] but will be reported again hereinafter to illustrate the evolution of clinical scores over time. For the present study, the authors recalled and reassessed all patients, 5 years later for clinical assessment (“second follow-up” at minimum 7 years) by an independent observer (AR), who collected IKDC-SKF, the Lysholm score, pivot-shift test, Lachman test, and signs of osteoarthritis (Fig. 1). None of the patients required additional surgeries (such as staple removal or meniscal repair) between first follow-up and second follow-up.



Fig. 1 Radiological assessment **A** preoperatively, **B** at first follow-up, and **C** at second follow-up

Statistical analysis

Due to the small sample size, the complete data for every patient was reported without statistical analysis, and the results were described in terms of the mean, standard deviation, and range.

Results

Out of the initial cohort of nine patients, seven were assessed at the clinic, one could only be assessed by telephone, and one was lost to follow-up. At final follow-up of 9.9 ± 3.0 years (7–15), the eight patients assessed, comprising five males (62.5%) and three females (37.5%), maintained or improved clinical scores since the previous follow-up at 4.0 ± 2.9 years (2–8) (Table 1). The mean Lysholm score further improved from 73.8 ± 5.8 (65–82) to 84.5 ± 11.9 (59–95). The mean IKDC further improved from 71.6 ± 6.2 (62–79) to 82.9 ± 12.1 (61–98).

The mean flexion increased from $130^\circ \pm 6.1^\circ$ (120° – 140°) at the previous follow-up to $137^\circ \pm 2.7^\circ$ (135° – 140°) the final follow-up. Of the two patients that had hyperextension of 5° at previous follow-up, the hyperextension at final follow-up increased to 10° in one patient, while it remained at 5° for the other patient. Both the Lachman test and pivot-shift test were negative in all patients at last follow-up, and none of the patients had retears or reoperations.

Of the three patients that had signs of arthritis at the previous follow-up; the stage of osteoarthritis increased in one (from grade 2 to grade 3); remained unchanged in one; and could not be assessed in one.

Discussion

The most important finding of the present study was that at 7–15 years following second revision ACLR with TDO, patients maintained or improved clinical scores compared to the previous follow-up at 2–8 years, without retears or reoperations. It is worth noting that, although eight of the nine knees had meniscectomies or meniscal sutures before or during TDO, osteoarthritis progressed in only one of the six knees that had signs of arthritis at the previous follow-up. These results suggest that TDO can protect the ACL graft from re-tear, with minimal progression of osteoarthritis and/or risks of meniscal tears.

Biomechanical studies have demonstrated that PTS has a linear relationship with the tensile forces exerted within the ACL [4], meaning that TDO would reduce strain on the ACL graft, especially during walking [13, 19, 26]. Furthermore, an increased tibial slope causes the tibiofemoral contact area to be shifted anteriorly, which can lead to decompression

of the posterior half of the plateau [1]. In addition, a study found that an increased PTS is associated with a higher pivot-shift and with greater risks of ACL rupture [5].

Several studies have demonstrated that there is an increased risk of osteoarthritis after ACLR [3, 20]. In the present series, of the six patients that had signs of arthritis at the previous follow-up; the stage of osteoarthritis increased by 1 grade in only two patients. Akoto et al. reported pre-operative osteoarthritis in 7 of their 20 patients (35%), but did not evaluate signs of osteoarthritis at final follow-up. The studies on second revision ACLR with TDO by Dejour et al. [8] and Sonnery-Cottet et al. [27], reported progression of osteoarthritis in two of the nine patients (22%), and in four of the five patients (80%), respectively.

In the present series, none of the patients had ACL retears, which is consistent with the two other published studies on revision ACLR with TDO [2, 27]; Sonnery-Cottet et al. [27] reported no retears at a follow-up of 2.5 years, and Akoto et al. [2] also reported no retears at a follow-up of 2.5 years. The re-tear rate reported for revision ACLR without TDO is much higher; 42% in a series of 44 knees [29]; 13% in a series of 15 knees [16]; and 21% in a series of 14 knees [12].

Compared to the previous follow-up, knee flexion has increased from 130° to 137° , and only two patients had asymptomatic recurvatum. Akoto et al. [2] also found 3 knees with asymptomatic recurvatum in a cohort of 20 patients. It is possible that TDO might cause slight genu recurvatum; therefore, an extension brace was used, similar to Akoto et al. [2] and Sonnery-Cottet et al. [27]. Furthermore, it was found that recurvatum did not affect the functional results.

In the present series, the IKDC and Lysholm scores improved in most patients between the previous (71.6 and 73.8 , respectively) and final follow-ups (82.9 and 84.5 , respectively), which exceeded the minimal clinically important difference (MCID) of 10.8 – 16.4 for IKDC, and 4.2 – 10.5 for Lysholm [24]. This could be explained considering that all patients had undergone 3 ACLR surgeries, which probably induced long-term apprehension, that had a greater effect at the previous follow-up than at final follow-up. It is also worth noting that pain and instability are the largest components of the IKDC and Lysholm scores, and that an improvement by 1 increment in either component increases the scores by 5 points. The IKDC score in the present study also compared favorably to studies on revision ACLR without TDO (61.7 – 80) [12, 16, 29], and was higher than that reported by Sonnery-Cottet et al. [27] on second revision ACLR with TDO (79.1) [27], probably because in the latter series, TDO was performed with tibial tuberosity osteotomy, which our technique does not require. The Lysholm score in the present study was, however, lower than studies on revision ACLR with TDO (87.8 – 90.9) [2, 27], but within the

Table 1 Demographics and clinical assessment per patient

	Patient 1	Patient 2	Patient 3	Patient 4	Patient 5	Patient 6	Patient 7	Patient 8	Patient 9
Sex	Female	Male	Female	Female	Male	Male	Male	Male	Male
Age (at TDO)	26	30	49	25	26	30	34	21	24
BMI	NA	25.9	20.9	19.8	NA	24.7	26.0	28.5	26.2
Side	Right	Right	Right	Right	Left	Right	Left	Left	Left
Time between injury and first revision (years)	2.7	0.7	9.8	6.4	5.0	2.2	6.8	4.3	5.6
Time between first revision and second revision with TDO (years)	5.2	3.5	3.5	1.5	0.8	2.2	0.8	2.8	4.6
Last follow-up (years)	8.8	6.9	7.2	7.4	NA	9.4	11.4	13.6	14.5
PTS									
Prior to TDO	15	12	10	15	10	13	18	14	12
First follow-up (2–8 years)	2	2	4	6	8	3	7	2	6
Medial meniscus status									
Prior to TDO	M		M			M	M	S	M
At TDO		M		M	S				M
Lateral meniscus status									
Prior to TDO									M
At TDO	M	S	M	M	N	M	M	M	
Medial compartment osteoarthritis grade									
Prior to TDO	0	0	1	0	0	0	0	1	1
First follow-up (2–8 years)	0	0	2	0	1	0	0	1	2
Second follow-up (7–15 years)	NA	0	2	0	NA	0	0	3	2
Lateral compartment osteoarthritis grade									
Prior to TDO	0	0	2	0	0	0	0	0	1
First follow-up (2–8 years)	0	0	2	0	1	0	0	0	2
Second follow-up (7–15 years)	NA	0	3	0	NA	0	0	0	2
Lysholm									
Prior to TDO	29	35	34	80	35	43	32	34	24
First follow-up (2–8 years)	82	80	76	78	74	68	73	65	68
Second follow-up (7–15 years)	59	93	87	93	NA	95	76	86	87
IKDC									
Prior to TDO	29	44	48	75	35	45	54	30	23
First follow-up (2–8 years)	82	78	79	73	74	66	74	62	64
Second follow-up (7–15 years)	61	91	77	89	NA	98	75	93	79

M meniscectomy, *N* normal, *S* suture

range reported for revision ACLR without TDO (69.9–87) [11, 16, 29]. A recent comparative study by Lefevre et al. [22] reported significantly lower subjective IKDC scores at 1 year follow-up for 55 revision procedures than for 497 primary procedures; this might explain the better scores achieved in the series of Akoto et al. [2], as it included many primary ACLR procedures.

The present study has a number of limitations, including the small sample size, losses to follow-up despite the

authors' efforts to contact all patients multiple times, lack of control group, heterogeneity in patient characteristics and adjuvant Lemaire procedures in four knees. Furthermore, the small sample did not allow for subgroup or uni- and multi-variable regression analysis to identify the influence of pre-operative characteristics on clinical outcomes, which may leave uncertainties on the outcomes of the surgery. A strength of the study is the long-term follow-up of 7–15 years, as well as the consistency of the surgery,

performed by the same experienced surgeon. The clinical relevance of these findings is that correction of excessive tibial slope should be considered when performing ACLR, whether the second or first revision, or even the primary procedure.

Conclusion

At 7–15 years following second revision ACLR combined with TDO, patients maintained or improved clinical scores compared to the previous follow-up at 2–8 years, while preventing retears or need for reoperations. It is worth noting that, although eight of the nine knees had meniscectomies or meniscal sutures before or during TDO, osteoarthritis progressed in only one of the six knees that had signs of arthritis at the previous follow-up. These results confirm that TDO can protect the ACL graft from re-tear, preventing deleterious evolution of failed ACLR, with minimal progression of osteoarthritis and/or risks of meniscal tears.

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Declarations

Conflicts of interest AR has nothing to declare. FVR has nothing to declare. GD has nothing to declare. MS has nothing to declare. Dr. Dejour reports personal fees from SBM, outside the submitted work.

Ethical approval All patients had provided written informed consent for the use of their data and images for research and publishing purposes and the institutional review board approved the study in advance (GCS Ramsay Santé pour l’Enseignement et la Recherche, COS-RGDS-2021-03-008-DEJOUR-D).

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