

# Revision anterior cruciate ligament reconstruction with ipsi- or contralateral hamstring tendon grafts

Claudio Legnani<sup>2</sup> · Giuseppe Peretti<sup>2,3</sup> · Enrico Borgo<sup>1</sup> · Stefania Zini<sup>4</sup> · Alberto Ventura<sup>1</sup>

Received: 30 May 2016 / Accepted: 15 December 2016 / Published online: 4 January 2017  
© Springer-Verlag France 2017

## Abstract

**Objectives** With the increasing number of primary anterior cruciate ligament (ACL) reconstructions, the need for revision ACL surgery has risen over the past few years. The purpose of the present study is to retrospectively compare the clinical outcome of ipsilateral versus contralateral hamstring tendon autografts for ACL revision surgery, specifically with regard to patient satisfaction, post-operative functional outcomes, and return to sports.

**Methods** Between 2004 and 2011, 64 patients underwent ACL revision surgery. Forty-five were successfully recontacted and retrospectively reviewed at an average follow-up of 6.3 years. Twenty-two subjects underwent revision ACL reconstruction with ipsilateral autogenous hamstring tendon grafts; in 23 subjects contralateral hamstring were used for reconstruction. Clinical, arthrometric, and functional evaluations were performed. The Tegner activity level, Knee Injury and Osteoarthritis Outcome Score (KOOS), and International Knee Documentation Committee (IKDC) Subjective Knee Form were used. Objective evaluation included range of motion, Lachman test, pivot shift test and KT-1000 instrumented laxity testing.

**Results** No major complications were reported. Follow-up examination showed that there were no significant

differences in the IKDC and KOOS scores between the groups. No differences in anterior tibial translation as measured with KT-1000 arthrometer were reported between the groups, although there was a trend for more of the patients undergoing ipsilateral DGST reconstruction to have a glide on the pivot shift test. The percentage of patients returning to pre-injury level was high in both groups.

**Conclusions** The use of contralateral hamstring tendon autografts for ACL revision surgery produced similar subjective and objective outcomes at 6-years follow-up compared to revision with ipsilateral hamstring tendon autografts. Patients undergoing revision surgery with contralateral autografts experienced a quicker return to sports compared to patients who underwent ipsilateral DGST revision surgery.

**Keywords** Anterior cruciate ligament · ACL revision surgery · Ipsilateral · Contralateral

## Introduction

Revision anterior cruciate ligament (ACL) surgery is recommended for patients who have symptomatic objective patholaxity after a failed primary ACL reconstruction. The number of revision ACL surgery has risen over the past few years [1].

The choice of graft in revision surgery remains a debatable issue. Autografts constitute a popular choice as many authors recommend autografts for both primary and revision ACL reconstructions [2–7]; the bone–patellar tendon–bone (BPTB) is frequently used as preferred graft source for ACL reconstruction in case of hamstring failure and vice versa [8].

✉ Claudio Legnani  
clegnan@alice.it

<sup>1</sup> Sports Traumatology and Minimally Invasive Articular Surgery Center, San Siro Clinical Institute, Milan, Italy

<sup>2</sup> IRCCS Galeazzi Orthopaedic Institute, Milan, Italy

<sup>3</sup> Department of Biomedical Sciences for Health, University of Milan, Milan, Italy

<sup>4</sup> Scuola di Specializzazione in Ortopedia e Traumatologia, Policlinico Universitario P. Giaccone, Palermo, Italy

Post-operative donor-site morbidity and anterior knee pain following ACL surgery may result in substantial impairment for patients. Intraoperative injury to the infrapatellar nerve can lead to donor-site discomfort and kneeling impairment [9].

To minimize donor-site morbidity in a previously operated knee, contralateral doubled gracilis and semitendinosus tendons graft (DGST) or BPTB have been proposed as a viable option for ACL revision surgery [8, 10].

The aim of this study is to compare the clinical outcome of ipsilateral hamstring tendon autografts versus contralateral DGST for ACL revision surgery, specifically with regard to patient satisfaction, activity level, and post-operative functional outcomes.

## Patients and methods

### Patients recruitment

Between 2004 and 2011, 64 patients who had previously primary ACL BPTB reconstruction underwent revision ACL surgery at the Minimally Invasive Articular Surgery Unit of the G. Pini Orthopaedic Institute of Milan.

Forty-five of them were successfully recontacted and retrospectively reviewed at an average follow-up of 6.3 years (range 2–9 years). Inclusion criteria were failed primary ACL reconstruction using a BPTB graft, confirmed by recurrence of giving-way episodes as revealed by a positive Lachman and pivot shift tests. Exclusion criteria were multiligamentous incompetence, contralateral instability or other significant knee disease, severe chondral damage (grade 3 or 4 of the Outerbridge classification system), or degenerative arthritis (Ahlback grade 3 or 4).

In most subjects (87%), ACL re-injury resulted from noncontact or indirect contact mechanisms. All other patients experienced a direct contact injury.

Twenty-two subjects underwent revision ACL reconstruction with ipsilateral autogenous hamstring tendon grafts; in 23 subjects contralateral hamstring were used for reconstruction. The median time since the first reconstruction was 45 months (range 18–142) in the ipsilateral tendon group and 40 months (range 20–128) in the contralateral tendon group. Table 1 shows complete demographic and anthropometric data.

Written informed consent was obtained. The study was conducted according to the guidelines expressed by the Ethical Committee of the Institute.

### Surgical technique of ipsilateral DGST reconstruction

Preliminary arthroscopic inspection was performed in order to confirm the diagnosis. Patients were excluded from the

study when intraoperative findings did not match inclusion criteria.

Hamstring tendon autografts were harvested from the ipsilateral knee with a tendon stripper through an incision over the pes anserinus on the AM aspect of the tibia and then prepared to form a 4-stranded replacement graft. The tibial and femoral tunnels were drilled with an arthroscopically assisted transtibial technique. After the remnants of the torn ACL were removed, the tibial tunnel was drilled with the aid of a guide (Acufex; Smith & Nephew, Andover, MA) at a 55 angle in the horizontal plane on the tibial plateau. The femoral tunnel was then drilled with the knee flexed from 90 to 120 in the intercondylar notch posterior and lateral on the medial aspect of the lateral femoral condyle to a depth of 30 mm and a diameter matched to the width of the prepared graft, at the 11 o'clock position in a right knee and at the 1 o'clock position in a left knee. Then, the graft was fixed proximally with the use of a TightRope device (Arthrex, Naples, FL). Distal locking was achieved through a BioRCI screw (Bioadsorbable Rounded Cannulated Interference; Smith & Nephew), having a diameter 1 or 2 mm larger than that of the graft, while the knee was kept at 20 of flexion under maximal manual tension.

### Surgical technique of contralateral DGST reconstruction

Operations were carried out in the same way with the exception that hamstring tendon autografts were harvested from the contralateral knee.

### Rehabilitation protocol

For the first 4 weeks, walking with partial weight bearing was allowed with the use of 2 crutches. Patients were encouraged to regain proprioception with the use of a balance board and complete knee flexion and extension. Closed kinetic chain exercises were performed for the first 3 months, and thereafter, open kinetic chain exercises were started. Swimming and indoor cycling were permitted after 12 weeks, jogging and noncontact sports were permitted after 5 months, and a return to contact sports was allowed after 6 months.

### Follow-up assessment

Patients were evaluated pre-operatively and after an average follow-up of 6.3 years (range 2–9 years). Assessment included Knee Osteoarthritis Outcome score (KOOS), International Knee Documentation Committee (IKDC) Subjective Knee Form, Tegner activity level, and objective examination including instrumented laxity test with KT-1000 arthrometer (MEDmetric Corporation, San Diego,

**Table 1** Patient demographics and anthropometric data

	Ipsilateral DGST	Contralateral DGST
No. of patients	22	23
Gender		
Male	16	14
Female	6	9
Mean time from re-injury to surgery (SD) (months)	10.0 (6.6)	8.6 (1.4)
Age at surgery (SD) (years)	27.1 (9.8)	26.8 (8.8)

*DGST* doubled gracilis and semitendinosus tendons graft, *SD* standard deviation

**Table 2** Overview of the results of clinical assessment

	Pre-operative	Post-operative	<i>p</i> value
KOOS score (mean, SD)	61.8 (SD 9.4)	84.9 (SD 6.7)	<i>p</i> < 0.001
IKDC subjective score (mean, SD)	29.2 (SD 10.4)	81.1 (SD 6.4)	<i>p</i> < 0.001
Tegner activity level (mean, range)	6.5 (range 4–10)	7.5 (range 7–10)	<i>p</i> < 0.001
Lachman sign (positivity)	45/45 (100%)	1/45 (2%)	<i>p</i> < 0.001
Pivot shift sign (positivity)	45/45 (100%)	4/45 (9%)	<i>p</i> < 0.001
Mean side-to-side anterior laxity in mm (mean, SD)	5.8 (SD 1.8)	1.8 (SD 2.4)	<i>p</i> < 0.001

*SD* standard deviation

CA, USA) under a 134-N anterior tibial load. Patients' evaluations were performed by the same equipe.

### Statistical analysis

Data extracted were analyzed using the program SPSS version 19.0 (SPSS Inc., Chicago, IL, USA). Wilcoxon test was utilized to compare the pre-operative and follow-up status and the difference between the two groups. Differences with a *p* value < 0.05 were considered statistically significant.

### Results

No cases of infection, deep thrombosis, neurovascular injury, or any other major complications were reported.

Subjectively, all patients were satisfied with their revision ACL reconstruction. The mean overall KOOS score increased (*p* < .001) from a pre-operative mean of 61.8 (SD 9.4) to 84.9 (SD 6.7), showing a statistically significant difference (*p* < .001). IKDC subjective score improved from 29.2 (SD 10.4) to 81.1 (SD 6.4) (*p* < .001). The median Tegner activity rating significantly improved (*p* < 0.001) from a pre-operative mean of 6.5 (range 4–10) to 7.5 (range 7–10). The outcomes of clinical assessment regarding Lachman test and pivot shift sign were clearly improved when compared with pre-operative status. The mean side-to-side KT-1000 value was 1.8 mm (SD 2.4). Of the patients, 43 (96%) reported a value equal to or less than

3 mm compared with the contralateral knee. Thirty of 45 (67%) achieved a return to pre-primary ACL reconstruction activities. A detailed overview of the results of overall clinical assessment is shown in Table 2.

The differences in the outcomes between the two groups are reported in Table 3. Using Wilcoxon test, there was no significant difference for subjective scores and activity level between the two groups with regards to point scales (*p* = n.s.). The percentage of patients returning to pre-injury level was high in both group; 58% of patients returned to cutting and pivoting sports, (Table 4). Anterior tibial translation according to manual laxity testing and as measured with KT-1000 arthrometer was not statistically different in the two groups (*p* = n.s.). With regards to return to sports, patients undergoing revision surgery with contralateral autografts experienced a quicker return to sports compared to patients who underwent ipsilateral DGST revision surgery.

No subjective loss of motion or strength of the contralateral knee, rotational injuries following tendon harvesting nor long-term significant morbidity at follow-up was reported.

### Discussion

The use of contralateral hamstring tendon autografts for ACL revision surgery produced similar subjective and objective outcomes at 6.3-year follow-up compared to revision with ipsilateral hamstring tendon autografts.

**Table 3** Overview of the results of clinical assessment at follow-up between the two groups

	Ipsilateral DGST	Contralateral DGST	<i>p</i> value
KOOS score (mean, SD)	85.6 (SD 6.8)	84.7 (SD 5.7)	<i>p</i> = n.s.
IKDC subjective score (mean, SD)	81.9 (SD 5.0)	81.0 (SD 7.3)	<i>p</i> = n.s.
Tegner activity level (mean, range)	7.5 (range 6–10)	7.8 (range 7–10)	<i>p</i> = n.s.
Lachman sign (positivity)	1/22 (4%)	0/23 (4%)	<i>p</i> = n.s.
Pivot shift sign (positivity)	3/22 (14%)	1/23 (4%)	<i>p</i> = n.s.
Return to sports rate	17/22 (77%)	18/23 (78%)	<i>p</i> = n.s.
Return to pre-injury rate	15/22 (68%)	16/23 (70%)	<i>p</i> = n.s.
Time to return to sports (mean, SD) (months)	14.3 (SD 2.2)	9.8 (SD 2.1)	<i>p</i> < 0.001
Mean side-to-side anterior laxity in mm (mean, SD)	1.8 (SD 2.4)	1.7 (SD 2.1)	<i>p</i> = n.s.

DGST doubled gracilis and semitendinosus tendons graft, SD standard deviation

**Table 4** Overview of sports activity pre-operatively and at follow-up

	Overall		Ipsilateral DGST		Contralateral DGST	
	Pre-injury	Post-operative	Pre-injury	Post-operative	Pre-injury	Post-operative
Jumping, pivoting, cutting	32/45 (71%)	26/45 (58%)	16/22 (73%)	13/22 (60%)	16/23 (70%)	13/23 (56%)
Swimming, cycling	13/45 (29%)	9/45 (20%)	7/22 (30%)	4/23 (17%)	7/23 (30%)	5/23 (22%)
No sports	0/45 (0%)	10/45 (22%)	0/22 (0%)	5/22 (23%)	0/23 (0%)	5/23 (22%)

DGST doubled gracilis and semitendinosus tendons graft

Patients undergoing revision surgery with contralateral DGST autografts experienced a quicker return to sports compared to patients who underwent ipsilateral DGST revision surgery. Both surgical techniques led to good results with improvement in knee stability and knee score values.

The present study shows favorable results for revision ACL reconstruction concerning subjective knee function and knee stability as well as ability to resume sport activities. Results are comparable to the most satisfactory outcomes reported in literature [1, 8].

Subjectively all patients reported that they would have the surgery again and were satisfied compared with their pre-revision status. After an average time of 6 years from surgery, mean KOOS was 84.9, while subjective IKDC score was 81.1.

No donor-site discomforts were reported by patients in our case series. Temporary loss of anterior sensitivity was reported in two patients 1 year after surgery, but recovered at follow-up. None of the patients experienced subjective loss of motion or strength of the contralateral knee or long-term significant morbidity at follow-up.

Our study shows no statistically significant differences with regards of knee stability between the two groups in ACL revision surgery. There was a trend for more of the patients undergoing ipsilateral DGST reconstruction (14%) to have a glide on the pivot shift test compared with the other cohort of patients (4%).

Shelbourne et al. [11] reported a rate to return to sports ranging from 62 to 74% in sportsmen who underwent revision ACL reconstruction with a patellar tendon autograft.

In our case series, 67% of patients were able to return to their pre-primary level of activity and sport. This result is in line with that of other studies with similar follow-up [12]. Revision ACL reconstruction either with ipsilateral or contralateral grafts may therefore be one possible option in patients with recurrent knee instability following primary repair who wish to return to their pre-injury activity level.

Patients undergoing revision surgery with contralateral autografts experienced a quicker return to sports compared to patients who underwent ipsilateral DGST revision surgery.

This may be explained since an ACL-reconstructed knee which is not affected by donor-site morbidity experiences a less aggressive surgical procedure. In fact, by harvesting hamstring from the contralateral limb, donor-site pain is shifted to the healthy side and allows the knee which is subjected to ACL reconstruction to an easier rehabilitation.

Therefore, reharvesting hamstring tendons in a previously ACL-reconstructed knee using patellar tendon may result in delayed return to sports compared to revision with contralateral hamstrings.

Limitations of the present study include the relatively small sample size. The limited study population may not have allowed for detection of small differences between

groups regarding some parameters. A greater number of patients in each group could have enhanced the statistical significance of the results obtained.

## Conclusions

The use of contralateral hamstring tendon autografts for ACL revision surgery produced similar subjective and objective outcomes at 6-year follow-up compared to revision with ipsilateral hamstring tendon autografts. Patients undergoing revision surgery with contralateral autografts experienced a quicker return to sports compared to patients who underwent ipsilateral DGST revision surgery.

## Compliance with ethical standards

**Conflict of interest** All authors declare that they have no conflict of interest.

**Ethical approval** All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Declaration of Helsinki and its later amendments or comparable ethical standards.

**Informed consent** Informed consent was obtained from all individual participants included in the study.

## References

- Kamath GV, Redfern JC, Greis PE, Burks RT (2011) Revision anterior cruciate ligament reconstruction. *Am J Sports Med* 39:199–217
- Colosimo AJ, Heidt RS Jr, Traub JA, Carlonas RL (2001) Revision anterior cruciate ligament reconstruction with a reharvested ipsilateral patellar tendon. *Am J Sports Med* 29:746–750
- Kamath GV, Redfern JC, Greis PE, Burks RT (2011) Revision anterior cruciate ligament reconstruction. *Am J Sports Med* 39:199–217
- Kartus J, Stener S, Lindahl S, Eriksson BI, Karlsson J (1998) Ipsi or contralateral patellar tendon graft in anterior cruciate ligament revision surgery. A comparison of two methods. *Am J Sports Med* 26:499–504
- Noyes FR, Barber-Westin SD (2001) Revision anterior cruciate surgery with use of bone-patellar tendon-bone autogenous grafts. *J Bone Joint Surg Am* 83-A:1131–1143
- Garofalo R, Djahangiri A, Siegrist O (2006) Revision anterior cruciate ligament reconstruction with quadriceps tendon-patellar bone autograft. *Arthroscopy* 22:205–214
- Noyes FR, Barber-Westin SD (2006) Anterior cruciate ligament revision reconstruction: results using a quadriceps tendon-patellar bone autograft. *Am J Sports Med* 34:553–564
- Ferretti A, Monaco E, Caperna L, Palma T, Conteduca F (2013) Revision ACL reconstruction using contralateral hamstrings. *Knee Surg Sports Traumatol Arthrosc* 21:690–695
- Kartus J, Magnusson L, Stener S, Karlsson J (1999) Complications following arthroscopic anterior cruciate ligament reconstruction. A 2–5-year follow-up of 604 patients with special emphasis on anterior knee pain. *Knee Surg Sports Traumatol Arthrosc* 7:2–8
- Rubinstein RA Jr, Shelbourne KD, Van Meter CD, McCarroll JC, Rettig AC (1994) Isolated autogenous bone-patellar tendon-bone graft side morbidity. *Am J Sports Med* 22:324–327
- Shelbourne KD, Benner RW, Gray T (2014) Return to sports and subsequent injury rates after revision anterior cruciate ligament reconstruction with patellar tendon autograft. *Am J Sports Med* 42:1395–1400
- Peterson RK, Shelton WR, Bomboy AL (2001) Allograft versus autograft patellar tendon anterior cruciate ligament reconstruction: a 5-year follow-up. *Arthroscopy* 17:9–13