Lateral tenodesis combined with anterior cruciate ligament reconstruction using a unique semitendinosus and gracilis transplant

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Abstract

Purpose The aim of this study was to assess the anatomical results, functional results and the incidence of arthritis of a mixed intra- and extra-articular hamstring tendon based reconstruction for anterior instability of the knee.

Methods This retrospective study consists of 100 knees in 99 patients (22 female and 77 male) operated upon between November 2003 and March 2006. The average age was 29.7 ± 10.4 years and the average interval between injury and surgery was 26.6 ± 41.8 months (2–240). In our technique, the semitendinosus and gracilis tendons were left attached to the tibia and by means of a lateral transcondylar tunnel posterior and inferior to the proximal attachment of the lateral collateral ligament were passed around the knee before being sutured to the fascia lata at the level of Gerdy's tubercle.

Results Sixty-eight knees were re-examined at an average follow-up of 76 ± 12 months. The average differential anterior drawer test at the last review was 2.5 ± 3.4 mm ($p < 0.0001$). Of the patients 75 % had a negative pivot shift test, 21 % a gliding test and 4 % a clear positive test ($p < 0.0001$); 84 % of patients had an International Knee Documentation Committee (IKDC) score rated A or B. The average IKDC subjective score was 90 ± 9 (60–100).

Conclusions Mixed intra- and extra-articular reconstructions using hamstring grafts allow the knee to be stabilised in the sagittal plane and the rotatory instability to be controlled in

the majority of cases. Only very minor progression of arthritic changes at an average 76 ± 12 months was seen.

Introduction

The Lachman test is easily and objectively quantifiable and as such has become the reference examination for confirmation of the efficacy of anterior cruciate ligament (ACL) reconstruction. Surgical techniques have been developed allowing correction of the anterior drawer laxity but which do not always sufficiently control instability in internal rotation [1]. Rotatory laxity or coronal laxity does not correlate with anteroposterior (AP) laxity [2] and can only be assessed in day-to-day clinical practice very subjectively by the pivot shift test. Unlike sagittal laxity, pre- and post-operative coronal laxity correlates with the functional results of ACL reconstruction [3] in terms of perception of stability, return to sport and overall patient satisfaction [4]. Furthermore, rotational instability increases the risk of meniscal and cartilaginous lesions and predisposes to arthritic changes [5]. As such, several strategies have been developed in an attempt to better control coronal stability including more lateral positioning of the femoral tunnel [6, 7], double-bundle reconstructions with a posterolateral bundle dedicated to controlling internal rotation [8, 9] and combined intra- and extra-articular techniques [10–15]. Such hybrid techniques allow the anterolateral stabilising structures to be reconstructed because they are always torn in cases of rotatory instability [16]. Indeed, biomechanical cadaveric analyses have shown that sacrificing the ACL in isolation does not increase laxity in internal rotation [17], whilst sacrificing both ACL and anterolateral stabilising structures significantly increases internal rotation [18]. The other benefit of lateral tenodesis is that it better controls internal rotation forces thanks to being further from the centre of rotation of the knee creating a longer lever arm as compared to an intra-articular reconstruction positioned close to the centre of the knee [19]. Current lateral tenodesis

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techniques are less invasive, preserve the anterolateral lock and allow for simple post-operative rehabilitation strategies [20].

The objective of this retrospective study was to evaluate the medium term results of an intra- and extra-articular reconstruction using a unique hamstring tendon graft in anterior knee laxities in patients meeting the following inclusion criteria: a differential laxity of greater than ten millimetres and/or a clear or huge positive pivot shift, sporting activities requiring knee rotation and previous failed anterior ligament reconstruction.

Materials and methods

Patients

Between November 2003 and March 2006, 100 knees were operated upon by a single surgeon (DS) in 99 patients. There were 22 female and 77 male patients with an average age of 29.7 ± 10.4 years (12–56). The average interval between injury and surgery was 27 ± 41 months (2–40) and none were operated upon in the acute or subacute period. The majority of patients were involved in contact sports involving pivoting (56) followed by contactless sports involving pivoting (37) and then contactless sports not involving pivoting (6). Of the patients 69 % complained of instability during activities of daily living; 44 patients were involved in competitive sports and 53 in recreational sports. There were 88 primary procedures and 12 revisions. Of the patients 22 had had a contralateral ACL rupture of which 19 had undergone reconstruction prior to inclusion in the study.

All patients were preoperatively examined under anaesthetic by the lead surgeon. Anterior laxity in 15° flexion was measured using the KT1000™ arthrometer (MEDmetric, San Diego, CA, USA) following the maximum manual Lachman (MML) test. The average laxity was 15.6 ± 3.5 mm (range 9–27) in terms of absolute laxity and 9.4 ± 4.4 mm (range –5–contralateral deficient ACL–to 18) for the differential value when compared to the contralateral side. We also assessed pivot shift and graded this as one cross (+) when there was a trace of a pivot (13 cases), as two crosses (++) when there was a clear pivot (70 cases) and three crosses (+++) when it was explosive (17 cases).

At the time of arthroscopic exploration we found 66 medial meniscus lesions and 60 lateral meniscus lesions. Only 14 knees had normal menisci (Table 1); 21 patients underwent partial medial meniscectomy, 17 a partial lateral meniscectomy, 14 a bilateral meniscectomy, three a medial meniscus repair and two a lateral meniscus repair (meniscal sutures were done when the meniscus was not stable). All cartilaginous lesions noted at the time of arthroscopy were recorded. We found 39 medial compartment lesions (15 grade 1, eight grade 2, ten grade 3 and six grade 4) and 24 lateral compartment lesions (nine grade 1, seven grade 2, six grade 3

and two grade 4). These lesions were mainly located at the level of the condyles. Preoperative radiographs were reviewed and analysed. This is summarised in Fig. 1a, b.

Operative technique

The pes anserinus tendons are harvested using a stripper through a small three to four centimetre incision and left in situ attached to the tibia (Fig. 2). The graft is fashioned from semitendinosus and gracilis and reinforced in its intra-articular portion by any excess semitendinosus (Fig. 3). The graft is typically 15–16 cm long and is passed into the knee under arthroscopic guidance through a transtibial tunnel created using a nine millimetre drill. It then exits via a lateral out-in transcondylar tunnel, inferior to the proximal insertion of the lateral collateral ligament (LCL), the knee being in flexion at 90° . A second lateral skin incision of approximately four to five centimetres then allows the graft to be tensioned towards Gerdy's tubercle (Fig. 4) where it can be attached to the fascia lata and held by five or six large absorbable sutures with the foot in a neutral position with no external rotation.

In the majority of cases (93 of 100) we augmented the transosseous fixation with an absorbable interference screw at the level of the tibia and the femur.

Assessment methods

All patients were reviewed by a single independent examiner (not the operating surgeon). Patients were asked if they had any instability symptoms either in their day-to-day or sporting activities. They were also asked to rate their satisfaction (very satisfied, satisfied, unhappy). We also asked whether they would have the procedure again and whether they would recommend the procedure to a relative. Patients were asked to rate their knee function on a scale of 0–100 and were asked to rate any pain using a visual analogue scale (0–10). In addition patients were asked if they had any pain at the level of the extra-articular tenodesis.

Objective measurements of active and passive range of movement of the knee and the presence or absence of any effusion were recorded. The Lachman test was performed using the KT1000™ comparing with the contralateral side as was the pivot shift test, which was used to evaluate rotatory instability. At review, patients were also scored using the 2000 International Knee Documentation Committee (IKDC) scoring system. Pre- and post-operative radiographs were also obtained (standing AP, lateral and squatting views). Ahlbäck's modified classification [21] was used to grade arthritic changes and the 2000 IKDC radiological criteria used with regard to our evaluation of medial and lateral tibiofemoral interline.

Statistical analysis was carried out using SAS Institute's StatView 5.0 software. A paired Student's *t* test was used to compare pre- and post-operative continuous variables. Co-

Table 1 Meniscal lesions found during arthroscopy ($n=100$)

	Medial meniscus	Lateral meniscus
Number	66	60
Bucket handle	28	16
Flap	1	6
Longitudinal slot	9	5
Horizontal cleavage	7	2
Transversal slot	0	9
Hypermobility meniscus	0	8
Menisco-capsular detachment	5	4
Spontaneous meniscectomy	9	4
Arthroscopic previous meniscectomy	7	6

variable analysis was also carried out (analysis of variance). To establish the link between two nominal variables we used the analysis of contingency tables and the χ^2 test in cases of non-paired data and the McNemar test for paired data. A p value of <0.05 was considered statistically significant.

Results

A total of 68 knees in 67 patients were reviewed at an average follow-up of 76 ± 12 months (60–90); two patients had died and the remaining 30 could not be reviewed either because they had left the area (11) or because they had been lost to follow-up (19).

Complications

Of the 68 knees reviewed, seven had required further surgery. Two patients at 1.5 years following their operation had recurrent instability (one traumatic graft rupture and one progressive distension of the graft without any obvious traumatic cause). The other operations were: one medial meniscectomy at four years post surgery, two lateral meniscectomies at five and seven years, respectively, one resection of a cyclops syndrome and one mosaicplasty of the weight-bearing area of the medial femoral condyle two years post-operatively (this had been planned from the time of the index surgery).

Fig. 1 a Medial femorotibial compartment: X-ray assessment according to the International Knee Documentation Committee (IKDC) rating system; squatting view at the latest follow-up ($p=0.01$). All numbers are percentages and D0 is day zero. **b** Lateral femorotibial compartment: X-ray assessment according to the IKDC rating system; squatting view at the latest follow-up ($p=0.03$). All numbers are percentages and D0 is day zero

Fig. 2 Semitendinosus and gracilis left attached at the level of their tibial insertion

Functional and anatomical results

The actual average anterior drawer near extension (Lachman test) was $9.5 \text{ mm} \pm 2.8 \text{ mm}$ (6–20) and the differential (side-to-side difference) was $2.5 \pm 3.4 \text{ mm}$ (–13–contralateral deficient ACL–to 11) representing statistically significant improvements of 6.1 mm ($p < 0.0001$) and 6.9 mm ($p < 0.0001$), respectively, with respect to preoperative laxity. With regard to pivot shift, we found a statistically significant improvement with no pivot in 75 % of cases, + in 21 % of cases, ++ in 4 % of cases and no +++ pivot. Of the patients 84 % had an IKDC objective score rated A or B (37 % A, 47 % B, 15 % C and 1 % D).

The average IKDC subjective score was 90 ± 9 (60–100); 90 % of patients had a score greater than 80 and 63 % a score greater than 90. The breakdown of the subjective scores is summarised in Table 2.

Fig. 3 Intra-articular part of the graft reinforced by excess semitendinosus

Fig. 4 Lateral extra-articular tenodesis fixed to fascia lata with five to six absorbable sutures

Radiological results

Of the knees 84 % were classed at stage 0, 15 % stage 1 and 1 % stage 2 based on modified Ahlbäck criteria [21]. Figure 1 details the results based on the IKDC criteria.

Discussion

Limitations of the study

Our study protocol is limited in that it is an uncontrolled retrospective single centre series. This is however mitigated

Table 2 Subjective results ($n=68$, follow-up= 6.3 ± 1 years)

Subjective IKDC	90±9 (60–100)
Satisfied or very satisfied (%)	93
Would have the procedure again (%)	97
Would recommend the operation (%)	99
Functional subjective value of the knee	84±12
Instability during daily living (%)	1
Instability at sport (%)	3
Type of sport	
Pivoting and contact sport (%)	43
Pivoting and contactless (%)	34
Not pivoting and contactless (%)	20
Sedentary (%)	3
Level	
Competitive (%)	30
Leisure (%)	63
Active (%)	4
Sedentary (%)	3
Pain at the level of the extra-articular tenodesis (%)	0

by our large numbers, the inherent homogeneity of a single surgeon series with a single operative technique, a single rehabilitation protocol, a single follow-up and a single independent reviewer. This adds validity to the results, which can be compared to other similar studies due to the use of well-known outcome measures and scoring systems.

Although our initial series was large in number, only 68 % of knees were available for review. This is a common problem in what it is a young and very geographically mobile population. There were no statistically significant differences in the characteristics of those lost to follow-up (age, sex, time interval to operation, initial laxity or associated lesions) and those reviewed for the purposes of this study.

Preoperative measurement of AP laxity was performed under anaesthetic by the operating surgeon using the KT1000™, whilst laxity measurement at follow-up was recorded in the clinic by an independent examiner. Sernert et al. [22] have shown that this measurement is very reproducible with little intra- or inter-observer variation and it does not vary under anaesthesia [23] like the pivot shift. However, the measurement of coronal laxity is less straightforward as evidenced by its many variants [24]. The pivot shift in particular is very subjective, of poor sensitivity and has a large inter-observer variation. Despite these limitations the pivot shift test remains the only practical clinical assessment of rotational laxity and for this reason this has remained part of our assessment. In order to limit any bias from this test all patients were reviewed and examined without anaesthetic by the same independent examiner.

Analysis of the results

Our anatomical results were very satisfying with 84 % of knees having an IKDC score of A or B despite a relatively high average age (30 ± 10 years), a long average interval to surgery of 27 months, some significant associated intra-articular lesions (only 14 of 100 knees had no meniscal pathology) and a high meniscectomy rate (more than 50 % of knees). Moreover, rotational laxity was well controlled (absence or trace of pivot in 96 % of cases).

Functional results were equally good: 97 % of knees entirely stable even during sporting activity; 93 % of patients were satisfied or very satisfied, whilst the subjective IKDC score was on average 90 ± 9 with 90 % of patients scoring over 80.

In terms of the evolution of cartilaginous lesions, 84 and 90 % of medial and lateral tibiofemoral joint lines, respectively, showed no signs of arthritic change (IKDC A or B); 50 and 26 % had mild modifications without narrowing of the joint space, respectively (IKDC B). Therefore, 45 % of the knees were rated as “radiologically normal”; this is in keeping with other data in the literature [25, 26]. These results were obtained despite the high number of meniscal and cartilaginous

lesions in our series; 99 % of knees were graded stage 0 or 1 by Ahlbäck's modified classification. Comparative analysis of preoperative radiographs and those taken at final follow-up was difficult because our preoperative imaging did not include an AP squatting view. When analysing results compartment by compartment with IKDC criteria, there is a statistically significant difference ($p < 0.05$) between the preoperative and final follow-up radiographs. Preoperative lesions have probably been underestimated by the absence of squatting radiographs.

These results are comparable to other hybrid reconstruction techniques. In 1995, using a MacIntosh quadriceplasty reinforced with a Kennedy ligament augmentation device (LAD), Saragaglia et al. [10] produced similar subjective and objective results with a minimum four year follow-up with what is a more invasive technique. In 2009, Marcacci et al. [27] in a prospective study with ten year follow-up reported their results of a mixed/hybrid technique similar to ours using hamstring tendons with a notch over the top of the lateral condyle and fixation of the extra-articular tenodesis with two staples (one at the level of the femur and one at the level of the tibia). Of the patients 97 % had an objective IKDC score of A or B, a negative pivot shift was noted in 94 % of patients and a mean subjective IKDC score of 93.

Studies comparing hybrid techniques with simple intra-articular grafting show variable results. O'Brien et al. [28] reported no improvement in AP laxity or patient-reported stability using an adjunctive extra-articular patellar tendon graft, but reported an increase in pain and joint effusion. Other studies are however strongly in favour of hybrid reconstruction techniques, although none of these have shown statistically significant results [15, 29–32]. In a recent prospective randomised study, Vadalà et al. [14] reported a better control of the rotatory laxity after lateral tenodesis combined

Fig. 5 Horizontal position of the femoral tunnel allowing better control of rotational laxity. On the AP view notice the tibial tunnel, which is very medial

with ACL reconstruction in female patients. Rotatory laxity has almost universally been measured clinically by means of pivot shift testing except by Lerat et al. [32] where they used lateral dynamic X-rays to separately measure the medial and lateral compartment AP laxity. They showed that whilst there was no difference in AP laxity of the medial compartment with mixed and simple intra-articular reconstructions there was better control of AP laxity of the lateral compartment with mixed reconstruction.

Otherwise, Zaffagnini et al. [33] published the only study comparing hamstring double-bundle reconstruction with mixed hamstring graft. Using intra-operative computer navigation they found that a hybrid reconstruction better controlled stability in internal rotation at 90° flexion as well as anterior laxity of the lateral compartment with Lachman testing. However, the double-bundle reconstruction better controlled pivot shift. As such, a mixed/hybrid hamstring reconstruction with its greater simplicity and reproducibility could be an alternative to the more technically demanding double-stranded reconstruction.

A common criticism of hybrid reconstructions has been the morbidity associated with graft harvesting, in particular anterior knee pain with patellar tendon grafts [34], and the potential for lateral destabilisation of the knee with fascia lata grafting. Use of the hamstring tendons and a simple lateral incision of three to five centimetres render the procedure simpler and comparable to intra-articular only reconstructions. Whilst lateral knee pain has been described with extra-articular grafts [28, 29] this was not seen in our series despite direct questioning about this; Acquitter et al. had similar results [30]. The use of staples to fix an extra-articular graft to Gerdy's tubercle may well contribute to this phenomenon. In our technique only simple heavy re-absorbable sutures are used to fix the graft at this level.

Stiffness has also been reported with mixed reconstruction techniques [29]. As the technique has become less invasive, however, stiffness is no longer seen to be a problem [30]. In our series no manipulation under anaesthetic or arthrolysis of the knee were carried out.

Others have commented on the arthrogenicity of mixed reconstructions [35]. This may be due to graft failure associated with extensive harvesting of anterolateral structures with some techniques, which leads to gaping of the lateral compartment during walking. It is also important to avoid fixing the graft with the knee in fixed external rotation as this decreases the physiological internal rotation. We recommend fixing the graft in neutral rotation with the knee flexed to 45° and the foot gently resting on its lateral border. We have always followed this method and have not seen any important worsening of cartilaginous lesions as evidenced by the fact that 99 % of our knees were classed as stage 0 or 1.

In our opinion, another important advantage of hybrid reconstructions is that a more coronal femoral tunnel leads to a

more anatomical intra-articular position of the graft (Fig. 5). The lateral entry point for the femoral tunnel with the knee in extension is just posterior to the lateral epicondyle or with the knee flexed at 90° just below the lateral epicondyle effectively passing from out to in. This gives the tunnel a coronal direction in the AP plane meaning that the intra-articular end of the tunnel is on the medial aspect of the lateral epicondyle in the 2 o'clock position (left knee). Thus the intra-articular part of the graft follows an oblique course from inside out allowing better control of rotational laxity [7, 17, 36, 37].

Conclusion

Mixed intra- and extra-articular reconstructions using hamstring grafts allow the knee to be stabilised in the sagittal plane and the rotatory instability to be controlled in the majority of cases. Secondary meniscal lesions were rarely seen demonstrating the quality of ligamentous repair achieved even in the presence of a large number of preoperative meniscal lesions and a long interval to surgery. Despite this, further prospective randomised controlled trials are required to fully evaluate the efficacy of this technique as compared to other single-bundle and double-bundle intra-articular ACL reconstructions.

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