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Single bundle reconstruction of the anterior cruciate ligament with four strands of the semitendinosus using the TLS technique. Clinical results of a series of 74 knees with a minimum of 18 months follow-up

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KEYWORDS
Anterior cruciate ligament; Hamstring tendons; Torn anterior cruciate ligament

Abstract The type of graft and the method of fixation in anterior cruciate ligament (ACL) reconstruction remains a subject for debate. The use of hamstring tendons reduces the morbidity of harvesting the graft relative to the patellar tendon but raises the question of the immediate stability of the graft, depending on the method of fixation. We present the results of our experience with the Tape Locking Screw (TLS) technique which provides good postoperative fixation of the graft. The hypothesis to be demonstrated was that the TLS technique gave results, in the short term, as good as those of the classic techniques with the patellar or hamstring tendons. It was a multicentre, continuous, prospective series of 82 patients operated for a unilateral rupture of the ACL. Fifty-eight sportsmen and 24 sportswomen with a mean age of 29 years underwent surgery performed by three surgeons in 2007. The TLS technique is based on five fundamental principles: harvesting only the semitendinosus tendon, preparation of a short four-stranded loop, strong prestressing of the loop, reaming of short femoral and tibial seating, screw fixation of each end via an intermediate polyethylene terephthalate tape. Postoperatively, the knee has free flexion without splinting and weight-bearing is possible from the start. Seventy-four patients were followed up after a mean of 24 months (18 to 36 months). The International Knee Documentation Committee (IKDC) subjective score rose from 68 to 92 points, the Lysholm score from 74 to 94 points, 14% of patients continued to experience moderate knee pain. The final objective IKDC score was: A: 31%, B: 43%, C: 23%, D: 3%. There were no general or infectious complications. Two patients had algodystrophy with functional sequelae, one patient had arthrofibrosis. The results are as good as those of the meta-analyses by Biau *et al.* in 2007 or Lewis *et al.* in 2008. The advantages of the TLS technique are: harvesting only the semitendinosus, solid primary fixation and simple immediate following procedures. This short-term study should be confirmed by a review at five years and other clinical studies.

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Levels of evidence. — IV (French grading).

Introduction

Reconstruction of the anterior cruciate ligament (ACL) of the knee is a frequent procedure in France (35,500 ACL reconstructions in 2006) but it still remains a subject of debate [1]. For many years, harvesting of grafts from the patellar tendon was considered the gold standard in primary reconstructions, because of its mechanical qualities (bone-bone fixation in the tunnels, screwing the bone plugs). Harvesting one or two hamstring tendons has gradually developed because of the lower degree of morbidity (reduced anterior knee pain, low risk of reduced mobility) but it has raised several questions: the quality of the initial fixation, the loss of ACL agonists. The many meta-analyses published have not significantly demonstrated that the patellar tendon is superior for postoperative stability, because of the poor methodological quality of the studies [2, 3]. One of the difficulties of interpretation is related to the great diversity of hamstring fixation methods (staples, screws, transfixing systems, endobutton, etc.) and levels of fixation relative to the patellar tendon, always fixed in the tunnel by interference screws [4, 5]. This has resulted in uncertainty in interpreting postoperative stability results, between insufficient stability of the fixation and the strength of the hamstring tendons. Michel Collette has been developing a new fixation system, the Tape Locking Screw (TLS), since 2003 [6]. It is based on five fundamental principles: harvesting only the semitendinosus tendon, preparing a short four-stranded loop, strongly prestressing the loop at 500 Newtons (N) for a maximum of 2 minutes, reaming short femoral and tibial seating, and screw fixation of each end via an intermediate polyethylene terephthalate tape. Postoperatively, the knee has free flexion without splinting, and weight-bearing is possible from the start.
The aim of this work was the subjective, objective and clinical evaluation of a series of 82 patients who underwent surgery for an ACL tear by the TLS technique using a single bundle reconstruction. The hypothesis to be demonstrated was that the TLS technique gave results, in the short term, as good as those of the classic techniques with the patellar tendon or hamstrings.

Patients and methods

This was a multicentre, prospective, continuous series of 82 patients. Those included were patients with a unilateral ACL tear who underwent surgery in 2007 performed by three surgeons experienced in arthroscopy who had mastered the TLS technique. The patients underwent surgery between two and 12 months after the trauma. Cases excluded were revisions of reconstructions, partial tears, reconstructions in children and bilateral tears. The series included 24 women and 58 men with a mean age of 29 years (14 to 51 years old) taking part in competitive (56%), regular (30%) and occasional (14%) sport. The side involved was the right in 45 cases and the left in 37 cases.
The semitendinosus graft was obtained by an oblique incision 3 to 4 cm below the interline, avoiding the sensory branches of the internal saphenous nerve. The graft was prepared on a special traction table in four or five equally tensioned strands forming a loop with a mean length of 50 mm. The loop was put under a strain of 500 N, for less than 2 minutes, using a tape at each end. The diameter of each end was carefully measured to be identical to the diameter of the femoral (length 10 mm) and tibial (length 15 mm) recesses. Each recess was drilled in a retrograde manner with a finned auger, in the normal femoral and tibial anatomical sites [7]. Reconstructing the more isometric anteriomedial bundle was preferred. The graft was introduced through the anteriomedial portal then successively penetrated the femoral and tibial tunnels. Each tape was fixed by a titanium TLS screw at the end of each tunnel. The tension and absence of conflict in extension were checked before closure. Postoperatively there was complete weight-bearing and free mobility without splinting. Gentle physiotherapy was undertaken in the patient's local clinic.
All the patients accepted prolonged monitoring of their knee given that they knew that the technique was recent and being evaluated. At visits they filled out a subjective pre- and postoperative evaluation form so that IKDC subjective, Lysholm and Tegner scores could be established [8-10]. This evaluation was undertaken in the absence of the surgeon, who was however available to help with understanding certain questions. Objective evaluation of the knee was undertaken pre- and

postoperatively by the surgeon, based on mobility in flexion-extension, the Lachman test, the pivot-shift test, and the anterior drawer test. Arthrometry was measured by an examiner independent of the surgeon using the GNRB® arthrometer at 134 N and 250 N (surgeon 1) and the Telos stress device at 200 N (surgeons 2 and 3) [11].
The pre- and postoperative results (subjective and objective IKDC scores, Lysholm and Tegner scores) were compared with Student's test. The *p* threshold of 5% was chosen as statistically significant.

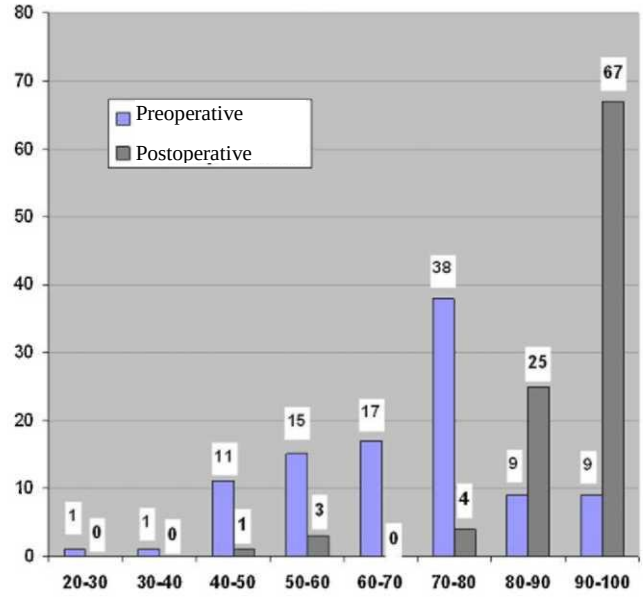

Figure 1. Subjective pre- and postoperative scores at a mean follow-up of two years.

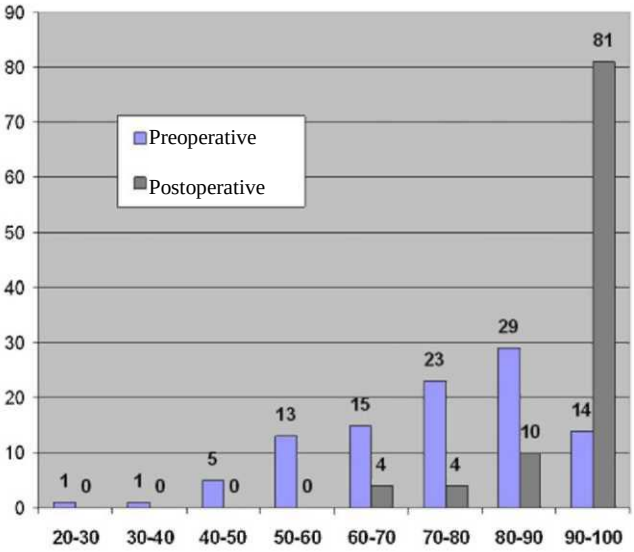

Figure 2. Lysholm pre- and postoperative scores at a mean follow-up of two years.

Results

Seventy-four patients out of 82 were seen again after a mean period of 24 months (18 to 32 months). Eight patients were not seen again after one year and were not included in the final follow-up. Forty-three knees presented a meniscus lesion: 20 involved the medial meniscus, 17 the lateral meniscus and six had mixed involvement. Nineteen had not been treated. Partial meniscectomy had been performed in 23 cases, and seven lesions had been sutured endoscopically.

Preoperatively, the mean pain score of the knee was 3.4 on a scale from 0 to 10. At the last check, this value was 1.1 (statistically significant reduction [p< 0.0001]). Eight per cent of the patients assessed their pain as slightly more intense postoperatively (an increase of 1 or 2 points). There was no residual pain on the screws after the longest follow-up, but one tibial screw was removed eight months after the operation.
The mean IKDC subjective score rose from 68 to 92 points after two years (p < 0.0001). All the patients except three (score less than 70 points) had improvement over their preoperative score by a mean of 39% (Fig. 1).
To the question: "Would you have the operation again", 86% replied "Yes", 10% "Perhaps" and 4% "No".
The patients' satisfaction score at three months was 8.3 points, and 9.1 at the final check. In three cases, the IKDC score was less than 70 points:

• one case at 48 points, because of algodystrophy, patellar tendinitis and a neuroma on the anteriomedial scar. This patient was not satisfied (score of 2/10) and would not have the operation again;
• a case at 60 points, because of lack of extension of more than 10°, resulting from algodystrophy;
• a case at 64 points, related to a 3° extension and a 10° flexion deficiency.

The mean Lysholm Score increased from 74 to 94 points after 24 months (p < 0.0001) and was stable between one and two years (Fig. 2).
The preoperative IKDC objective score was distributed as follows: A: 1%, B: 4%, C: 60%, D: 35%, and after the longest follow-up the score was: A: 31%, B: 43%, C: 23%, D: 3% (Fig. 3).
Table 1 shows the answers to the following question: What is the greatest level of activity that you can achieve without your knee giving way? Twenty-two percent of patients had not recovered complete confidence in their knee.
In 44 cases, laxity had been measured with a Telos stress device at 200 N. The mean differential fell from 5.9 mm preoperatively to 1.9 mm postoperatively (p< 0.0001). At 200 N, the frequency of laxity less than 3 mm was 84%.

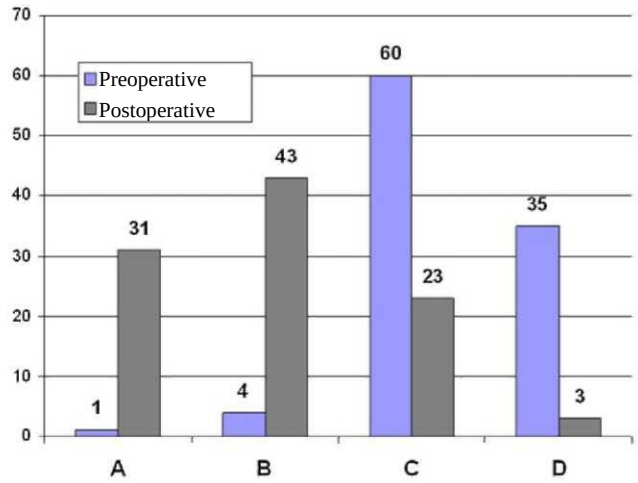

Figure 3. Pre- and postoperative objective IKDC scores at a mean follow-up of two years.

Table 1 Answers to the question: What is the greatest level of activity that you can achieve without your knee giving way?

	Very intense activities	Intense activities	Moderate activities	Gentle activities	No activity
Preop (%)	2	14	46	37	1
> 18 months (%)	78	7	12	3	0

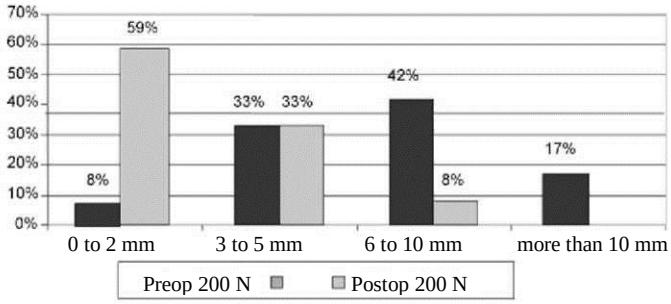

Figure 4. Percentage of differential laxity measured by a Telos stress device pre- and postoperatively in 44 patients (mean follow-up of two years).

In three patients, the differential laxity was greater than 6 mm (Fig. 4). In 29 cases, laxity was measured with a GNRB® arthrometer at 134 N and 250 N. (Fig. 5). At 134 N, the rate of laxity of less than 3 mm was 83%. At 134 N, there was one case of differential laxity of more than 6 mm but two cases if the force was increased to 250 N. Mean laxity fell from 6.7 mm to 1.7mm at 134 N and 1.9 mm at 250 N. At 250 N, the percentage of laxities between 3 and 5 mm or greater than or equal to 6 mm increased from 17 to 26%. The rate of laxity less than 6 mm with the two methods is similar, if the Telos at 200 N (92%) is compared with the GNRB® at 250 N (94%). There was no differential laxity of more than 10 mm with the Telos or the GNRB® at the longest follow-up. Five patients had laxity equal to or greater than 6 mm (measured with the Telos stress device or the GNRB® arthrometer with pressure higher than or equal to 200 N), which is not a hindrance in sporting practice. A positive pivot-shift was found in 16% of cases including one considered as 'pronounced' (Fig. 6). There was no revision for recurrence of a torn reconstruction.
Return to the preoperative sporting level was possible in 74% of cases, with a Tegner level of 7 ± 2.2 preoperatively and 6.3 ± 2 postoperatively.
There were no thromboembolic or infectious complications. One patient had the tibial screw ablated at eight months because of persistent pain, which was relieved.
Two patients had major algodystrophy with residual stiffness. One patient had arthrofibrosis with reduced extension (3°) and flexion (10°). One patient developed cyclops' syndrome which was treated arthroscopically six months postoperatively with good final results.

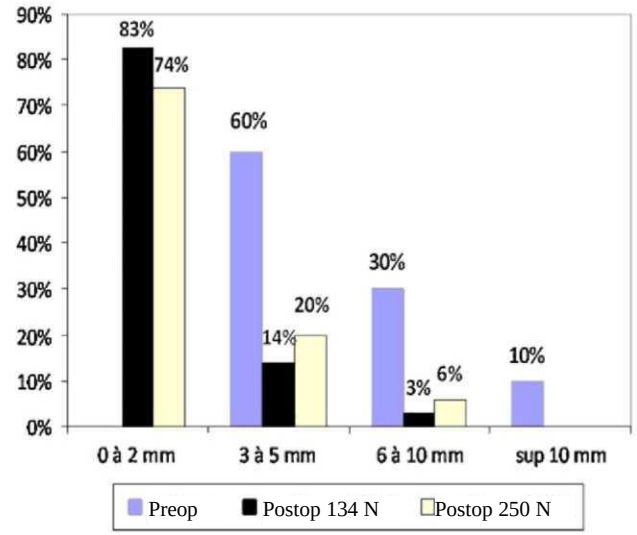

Figure 5. Percentage of differential laxity measured with a GNRB® arthrometer pre- and postoperatively at 134 and 250 N in 30 patients (mean follow-up of two years).

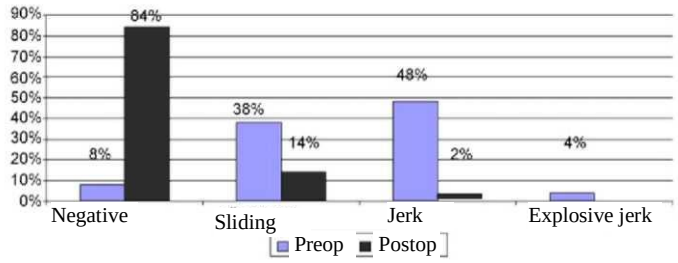

Figure 6. Percentage of pre- and postoperative positive pivot-shift test (mean follow-up of two years).

Discussion

This was the first study of clinical results of the TLS technique with a minimum follow-up of 18 months and a mean of two years. All the subjective and objective scores were improved significantly by the ligament reconstruction.

The mean IKDC subjective score after the longest follow-up was 92 points compared with a mean score in the 25 to 34-year-old age group of normal subjects (an American population with healthy knees) of 94 points [12]. The objective of restoring a 'normal' knee after ligament reconstruction was achieved for this age group. This score has to be taken into account, particularly for young subjects, for whom the norm before 24 years of age is 100 points. The mean IKDC subjective scores for the three surgeons were similar: 90 points (surgeon 1), 92 points (surgeon 2), 93 points (surgeon 3), which indicates that the technique is reproducible by experienced surgeons.

Residual knee pain was present but slight in 14% of the patients, which is lower than the 23% in the meta-analysis by Lewis *et al.* (eight randomised prospective studies including patellar and hamstring tendons) and identical to the meta-analysis by Biau *et al*. (13% in the series with hamstring tendons) [2]. Anterior pain was more common with the patellar tendon at 22% according to Biau *et al*. Residual pain may also be related to any meniscus procedure (meniscectomy or suture), more common if the period before surgery exceeds five months [13]. In our series, we did not identify the particular contribution of meniscal pain. We are still concerned with the occurrence of two cases of algodystrophy and one of arthrofibrosis with residual stiffness (loss of mobility in flexion or extension of 5° or more). Apart from these three cases, we did not see any loss of mobility greater than 5°. We consider the control of postoperative pain and monitoring physiotherapy to be important for early detection and treatment of these complications. Physiotherapy must not be painful or aggressive. The postoperative checks at six weeks and three months should warn of any complication and possibly lead to the physiotherapy being stopped.

The Lysholm Score increased from 74 to 94 points, which is comparable with the score of a population of the same age with healthy knees [14]. The meta-analysis by Lewis *et al*. found a Lysholm score of more than 85 points in seven studies out of eight [15].

In this study, the percentages for the IKDC objective A and B scores were respectively 31% and 43%, which is comparable to the meta-analysis by Biau *et al*. (14 randomised prospective studies included) where the percentages were 33% and 45% [16]. The meta-analysis by Lewis *et al*. reported 35% in class A and 44% class B, which is perfectly comparable with the series presented [15]. A positive pivot-shift was present in 16% of cases as against 19% in Lewis' study. The length of time before surgery is important for residual rotatory laxity: Harilainen *et al*. found positive pivot-shifts in the group of patients operated on after five years but not in the group undergoing surgery within a year [17].

Mean laxity measured using a Telos at 200 N decreased from 5.9 mm preoperatively to 1.9 mm postoperatively, with 84% of differential laxity less than 3 mm. These results are better than those in Lewis' series: 77% of patients had laxity measured with a KT-1000 of less than 3 mm [15]. The KT-1000 measurements were only recorded at 134 N and were therefore not under as much strain as at 200 N. With the GNRB® arthrometer, mean laxity fell from 6.7 mm to 1.7 mm for 134 N and 1.9 mm for 250 N. There were no repeated tears in this series (laxity of more than 10 mm) while Lewis *et al*. reported 3.5% of such tears [15].

There was a return to the preoperative level of sport in 74% of cases in our study, in 67% in the study by Biau *et al.* and 79% in the study by Lewis *et al*. Not returning to sport may be related to the knee (residual pain, loss of extension, muscular deficiency, etc.) but often reflects a lack of confidence, justified or not, or a lack of time or motivation for sport.
The hypothesis concerning good quality clinical results in the short term compared with other techniques has been confirmed.
The TLS technique has several advantages: a single hamstring tendon (semitendinosus) is taken, which does not seem to modify the results compared with taking both the semitendinosus and gracilis [18]; the initial stability of screw fixations allows weight-bearing without splinting and free mobilisation of the knee [6]; the secondary tendon/bone fixation is peripheral and there is a high degree of satisfaction from the third postoperative month (8.3 points).
This study has 3 weak points. The clinical laxity measurements (the Lachman and pivot-shift tests) were made by the surgeon, but the IKDC and Lysholm questionnaires were filled in and the Telos or GNRB® laxity measurements made independently of the surgeon. It was not possible to follow-up all the patients beyond 18 months; eight were only followed up for one year (90% follow-up rate). Finally, there was no group of patients that underwent surgery by the same surgeons using another technique.

Conclusion

This multicentre prospective study of 82 patients who underwent ligament reconstruction of the knee using the semitendinosus fixed by the TLS technique reports results at least as good as in other publications on the results of ligament reconstructions performed using the hamstring fixed by other methods. Mean subjective scores show recovery of knee function that is 'normal' for the age of the subjects. The objective scores are as good as those of reconstruction series using the patellar tendon. This preliminary, short-term study should be confirmed by following up at five years and by other clinical studies.

Conflict of interests

The authors declare that they have no conflicts of interest relating to this paper.

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