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TECHNICAL NOTE

The Tape Locking Screw technique (TLS): A new ACL reconstruction method using a short hamstring graft

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Summary   The Tape Locking Screw (TLS®) system, developed in 2003, is a new anterior cruciate ligament (ACL) reconstruction method that is based on three principles: one hamstring tendon is harvested, prepared into a short (50 to 60 mm), four to five strand closed loop, with a diameter of 8 to 10 mm and a 500 N pre-load; the tunnels are shorter than usual (10 or 15 mm) and created in a retrograde manner to match the diameter of each end of the graft. Maximum press-fit into the bone recesses is obtained by a specific graft introduction method; femoral and tibial fixation is provided by polyethylene terephthalate tape strips, or TLS® strips, that pass through each end of the closed tendon loop and attach to bone with a dedicated interference screw, the TLS® screw. Our preliminary clinical evaluation consisted of a follow-up of 134 patients.

Introduction

Although the use of a hamstring graft for anterior cruciate ligament (ACL) reconstruction is growing, certain technical problems remain to be solved. Solid, reproducible anchoring and equal graft loading are difficult to achieve [1]. The risk of graft-fixation complex elongation [2,3], tunnel widening [4], and loss of muscle strength after harvesting of two hamstring tendon grafts [5,6] also present a challenge. The

Tape Locking Screw (TLS®) system (FH Orthopedics[1]) aims to meet these challenges while maintaining the minimally invasive feature of existing techniques.

The TLS® system is based on three technical principles: graft preparation, bone tunnel shape and a novel fixation method.

- Graft: a short (50 to 60 mm), 8 to 10 mm diameter closed tendon loop is prepared from a single hamstring tendon. The TLS® strip, which is composed of 7 mm braided

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polyethylene terephtalate, is passed through each end of the tendon loop. A 500 newton (N) preload is then applied.

- Bone tunnels: Small diameter (4.5 mm) bone tunnels are made by outside-in aiming on the tibia and femur. The bone recesses are hollowed out using a dedicated retrograde reamer.
- Fixation: tibial and femoral fixation is ensured by screwing the graft suspension strips from outside-in with a dedicated interference screw (TLS® screw).

Surgical technique

The TLS® requires that specific instrumentation be used.

Graft preparation

A short, oblique incision is made over the tibial insertion of the hamstring tendons and a single tendon harvested with a stripper. The semitendinosus is usually harvested, but the gracilis is sometimes harvested (failure of ST harvesting, multiple ligament repair, double bundle). The tendon is then rolled around two posts on the preparation table to produce a four or five strand closed loop (Fig. 1). The graft length is set at 50 to 60 mm, based on pre-operative radiographs, and corresponds to the sum of length of the intra-articular path of the ligament and the depth of the two tunnels. Two TLS strips are passed into each end of the loop and preloaded on the traction table at 500 N for one to two minutes (Fig. 2). The graft ends are measured to determine the diameter of the bone recesses that have to be made.
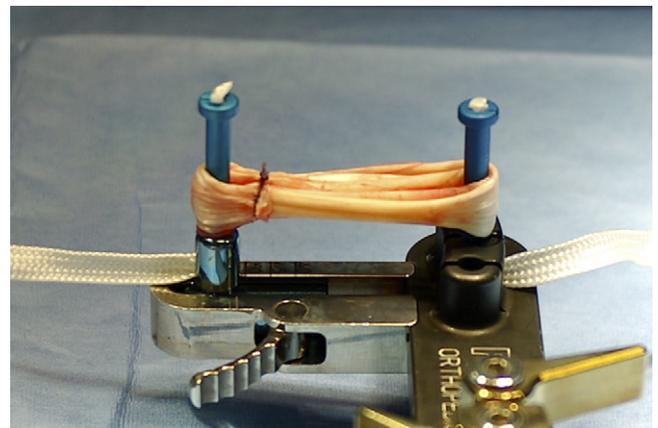

Figure 1   Graft preparation.

Figure 2   Preload is placed on graft.

Preparation of the tunnels and recesses

An arthroscope is placed in the inferior-lateral portal and the intercondylar notch is prepared in the typical manner. A dedicated drill guide is introduced into the anterior-medial portal. A 10 mm axial incision is performed on the lateral
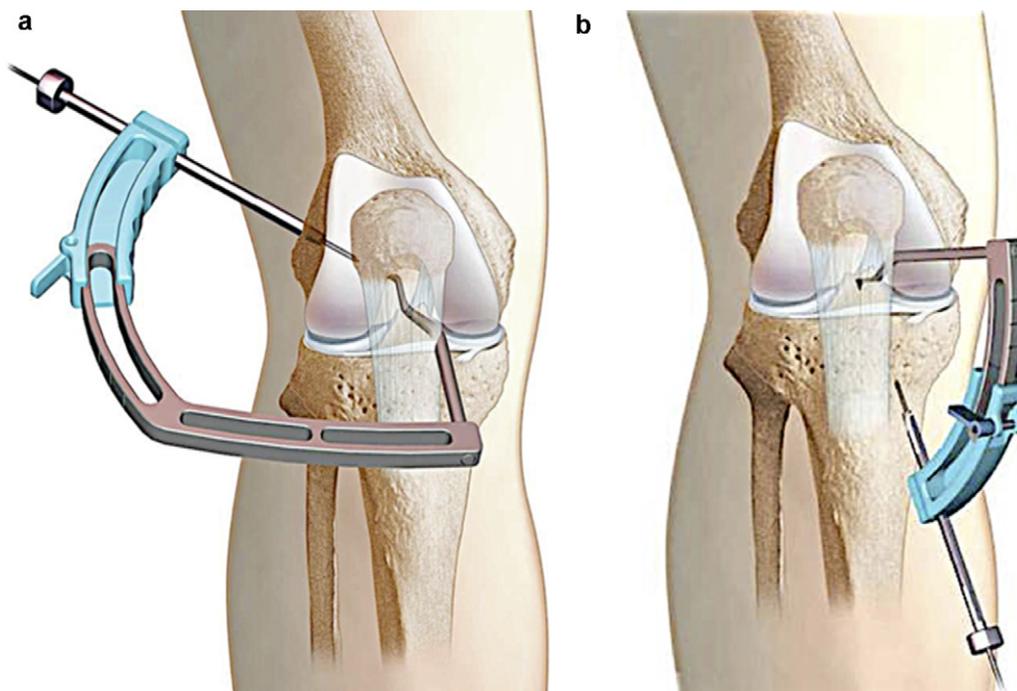

Figure 3   a: outside-in femoral targeting device; b: outside-in tibial targeting device.
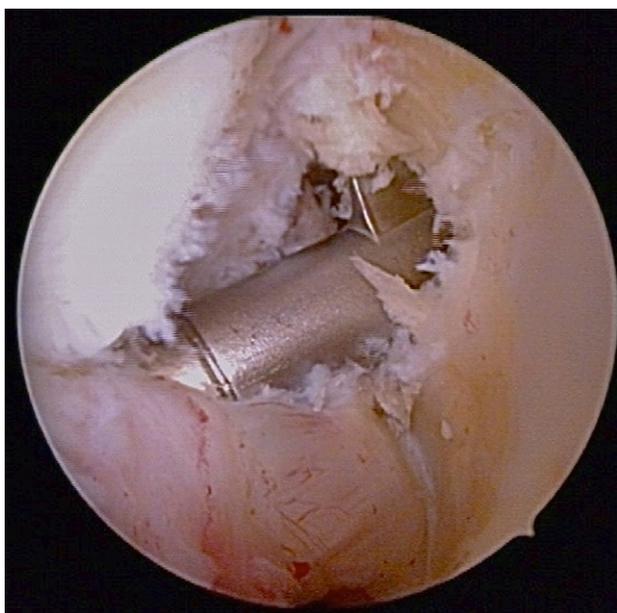
Figure 4   Retrograde reamer.

aspect of the knee for the femoral tunnel. An aiming barrel is introduced until it contacts the bone, and then tilted to about 45° relative to the frontal plane and diaphyseal axis (Fig. 3a). A guide-pin is inserted from outside-in so that it emerges in the middle of the chosen graft insertion area. Tibial aiming is also performed from outside-in (Fig. 3b), starting at the tendon harvesting site.

A 4.5 mm cannulated drill bit is used to drill the tunnel from outside-in along the path of the guide-pin.

The opening of each tunnel is tapped along the guide-pin to a length of 15 mm. The tibial and femoral recesses are then hollowed-out using a dedicated, retrograde reamer that is available in variable diameters (7—11 mm) (Fig. 4). The simultaneous backward and rotational movement of the reamer results in cutting of a cylindrical bone recess that is equal in diameter to the breadth of the fins (Fig. 5). The

Figure 5   Arthroscopy view of retrograde reamer as it hollows out the femoral bone recess.

Figure 6   TLS screw and appearance of the graft after fixation.

depth of the recess is systematically set to 10 mm on the femur and 15 mm on the tibia. An additional 4 to 5 mm depth in the tibia provides a margin of safety for graft placement. Cannulas are then screwed into the footprint left by the tap. These make tunnel access easier and act as supports when the strips are placed under load.

Insertion of the graft and fixation

The graft is introduced into the joint through a slightly widened, anterior-medial arthroscopy portal. The strips are recovered at the exit of each tunnel using a traction wire passed from outside-in. With a strong pull on the strips, the graft penetrates into the bottom of the femoral tunnel and then into the tibial tunnel. Once the graft's position and tension have been verified, fixation is performed using a specially designed conical screw that is 10 mm in diameter, has a specific footprint, and is available in two lengths (20 mm for the femur and 25 mm for the tibia). It is available in titanium alloy, Peek and biocomposite material (Fig. 6). Because of the initial preload on the graft, cycling movements are unnecessary. Finally, the strips are cut at the bone and the incisions are closed with or without drain, depending on surgeon preference.

Postoperative care

Full weight-bearing is allowed immediately without protective bracing. Range of motion is regained progressively, without restriction.

Results

The first 134 patients operated at three sites (Brussels; Dr Collette, Aix-en-Provence; Dr Calas, Toulouse; Dr Cassard) between September 2003 and August 2006 were seen again after six to 36 months. There were six failures (4.4%), three

infections (2.2%), two cases of thrombophlebitis (0.7%), two significant hematomas (1.4%), and one case of Type I complex regional pain syndrome. A few cases of hydrathrosis lasting more than three months were observed, however the frequency did not appear to be higher than with other procedures.

Differential laxity was measured with the technique used at each center and showed the following results:

- KT1000 with 30 lbs (13.6 kg) traction (20 cases): 1.5 ± 2.2 mm; maximum manual traction: 1.8 ± 2.2 mm
- TELOS® with 20 kg traction (56 cases): 1.7 ± 1.8 mm
- TELOS with 20 kg traction (58 cases): 3.7 ± 2.3 mm (includes failures)

Discussion

Hamstring tendon graft techniques have less morbidity than patellar tendon techniques for ACL reconstruction, however laxity is not as well controlled [7,8]. The relative mechanical weakness of hamstring tendon grafts is attributed to graft elongation and the quality of the fixation [2,3,9—11]. Furthermore, harvesting both the semitendinosus and gracilis tendons results in a force deficit in the knee flexors; this deficit can be reduced by harvesting only one of these tendons [5,6].

In the standard technique, harvesting a 25 cm length of both tendons provides a 10 to 12 cm graft, most of which is used to attach the 3 cm long, intra-articular portion of the graft [12]. Through the use of a shortened graft, the TLS® system solves many of the above problems. The tendon segment required to attach the functional 3 cm of graft is reduced to a minimum (10 mm at the femur and 15 mm at the tibia), since fixation is assured by textile pieces that are better suited to screwing than the tendon is. The second tendon is spared and available for special circumstances (double-bundle ACL, PCL, ACL + peripheral reconstruction, reconstruction of both cruciates, etc.). Furthermore, by providing two traction wires instead of one, the forces are equally distributed between the four strands of the closed loop, whereas with an open loop, the forces would be randomly distributed [13].

Static and dynamic tension testing of human semitendinosus tendons prepared into a closed loop (Mechanical laboratory at CRITT-Charleville, June 2002), have found that ultimate strength was near that of a normal ACL (1916 ± 349 N). However, the quality of secondary biological anchoring comes into question because of the reduced amount of tendon inserted into the bone tunnel. The shortened graft design has been validated in three experimental studies. In 2002, Weiler et al. [14] showed that the tendon attaches to bone tissue partly in the tunnel itself and partly where it enters the joint. Intratunnel healing only has a transient effect and fixation at the tunnel entry takes over during the third or fourth postoperative month. In 2008, Zantop et al. [15] showed in goats that using either 15 or 25 mm of tendon insertion in the femur does not result in any significant differences in knee kinematics or graft mechanical properties (pull-out strength, stiffness) at six and 12 weeks postoperative. Yamazaki et al. [16] have shown in dogs that at six weeks postoperative, tendon grafts placed

in bone recesses that were 15 mm or 5 mm deep had the same pull-out strength.

The fixation process itself has interesting subtleties. Because of their flexibility, the suspension strips are harmless for the tendon tissue. Long-duration cyclic loading trials found no signs of tendon tissue deterioration after 30,000 cycles with loads between 0 and 500 N (CRITT-Charleville, June 2002). There is 360° of contact between the bone and tendon in the tunnel and the fixation procedure does not change the position of the chosen insertion site. The detrimental effect induced by the separation of the fixation and the graft anchoring area in the joint is avoided [17]. Any breakage of the posterior wall of the femoral bone recess will not affect the sturdiness of the fixation, as it occurs further away. The TLS® screw attaches the strips that are in contact with the graft, which avoid the undesirable elasticity that occurs in typical suspension systems. The mechanical properties of this screw-tape strip unit were outstanding in our laboratory trials (CRITT-Charleville- June 2002). Static tension tests performed on this screw-tape strip unit anchored in human bone (femoral head) showed that pull-out strength was 1742 ± 397 N. This was maintained (1610 ± 414 N) after 1500 cycles of loading in tension (0 to 500 N). The results of these laboratory tests also led us to prestretch the tape strip-graft-tape strip complex before inserting it into the knee. With the TLS® system, the stretch occurs at the interface between the tape strip and tendon tissue, which flattens as interstitial liquid is pushed out, and lengthens 2 to 3 mm after two minutes of tension at 50 kg.

Since the preliminary study on patients operated between October 2003 and August 2006, more than 800 patients have been operated on with this system by the surgeons who were involved in its development. More than 13,000 cases have been performed with this technique since it was marketed in and outside of France starting in March 2007. A prospective study not involving the designers is ongoing and has promising results after 2+ years of follow-up.

Disclosure of interest

Dr Michel Collette: occasional consultant for FH Orthopedics.

Collection of royalties as designer of the TLS® system.

Dr Xavier Cassard: occasional consultant for FH Orthopedics.

Collection of royalties as designer of the TLS® system.

Acknowledgments

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