Technical Note

Seatbelt Anterior Cruciate Ligament Reconstruction: A Variant of Internal Brace in Anterior Cruciate Ligament Reconstruction With an Adjustable Loop

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Abstract: In recent years, there has been a growing interest in primary anterior cruciate ligament repair with the help of mechanical reinforcement techniques that employ synthetic grafting. The concept of ligament augmentation with reinforcement suture or internal bracing consists of stabilizing the repaired ligament and augmenting it with an ultra-high molecular weight polyethylene suture or tape, which guarantees greater resistance, safety during healing, and a more accelerated rehabilitation. In this work, we propose a variant of anterior cruciate ligament augmentation with suture, replacing the suture tape with an adjustable-loop reinforcement system, which is connected to the adjustable suspension devices for the graft in the femur and the tibia, surrounding the graft as a seatbelt.

Ligament suture augmentation (internal brace [IB]) has been described successfully in the repair of injuries of the anterior cruciate ligament (ACL) lesion. Initially, the technique was described for repairs of partial injuries of the proximal third, with preservation of the native ligament, but its use has been described from simple reconstruction to treat total ACL tears up to more complex techniques such as double-bundle ACL reconstruction, with anterolateral external reinforcement, and others in which a repair is combined with reconstruction using hamstring graft as a biological augmentation.[1,2]

Several techniques have been used for the reinforcement, which differ mainly in terms of material and fixation. A polyethylene suture tape (FiberTape; Arthrex, Naples, FL) is frequently used. However, some techniques have been described that take the leftover retrieving suture of the femoral cortical fixation system as an IB.[3] The synthetic graft can be fixed to the femoral cortex by means of a suspension button (suspensory adjustable device), whereas fixation to the tibia can be achieved with a knotless anchor type SwiveLock (Arthrex), or by tying the reinforcement to a cortical button if employed for graft suspension, such as a TightRope (Arthrex).[4]

In this work, we propose a variant of ACL augmentation with IB. We consider it an effective and reproducible technique because we use an adjustable loop as an internal reinforcement system, which is connected to the adjustable suspensory fixing devices on both the femur and the tibia.

Surgical Technique (With Video Illustration)

Patient Setup

The patient is placed in a supine position, with a side post at the level of the proximal thigh and a foot support.

Graft Harvest

The semitendinosus (ST) tendon is harvested with a minimally invasive anterior harvest technique, with a vertical incision 6 cm below the joint space and 2 cm medial to the tibial tubercle.[5]

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Implant and Seatbelt Preparation

Two adjustable juxtacortical fixation for bone–patellar tendon–bone (Pull-ups; SBM, Lourdes, France) are needed to prepare the SB ACL ligamentoplasty (Table 1) on each side of the graft preparation set (GraftTech; SBM) (Video 1). First, the 2 free strands from each adjustable juxtacortical fixation for bone–patellar tendon–bone (Fig 1) are introduced through the adjustable loop (TightRope, ABS; Arthrex) and then, each free strand from the adjustable juxtacortical fixation for bone–patellar tendon–bone grafts system must be passed through the nylon loop (Fig 2). Next, gentle traction should be applied, grabbing from the nylon knot with a final stronger pull so that each free strand goes through the suture sheath and through the adjustable juxtacortical fixation for bone–patellar tendon–bone button of the system, so that the adjustable juxtacortical fixation for bone–patellar tendon–bone grafts becomes a closed adjustable fixation system device. This step must be repeated for the same side for the other free adjustable juxtacortical fixation for bone–patellar tendon–bone grafts strand. At the opposite adjustable juxtacortical fixation for bone–patellar tendon–bone grafts, the adjustable loop must be passed in the same manner and the 2 free limbs must be passed as described in the text before for the first side, closing the loop in an adjustable manner in the femoral adjustable juxtacortical fixation for bone–patellar tendon–bone grafts as well as the tibial side (Fig 3).

Once the adjustable loop is within the femoral and tibial adjustable juxtacortical fixation for bone–patellar tendon–bone grafts, the graft is prepared (Fig 4). The adjustable loop must be kept without tension apart so that the ST graft can be loaded into the graft-preparation set (Table 2).

Table 1. Step-by-Step Description of Surgical Technique

Seatbelt set-up
Prepare one adjustable juxtacortical fixation for bone–patellar tendon–bone graft for the femoral side and one XL adjustable juxtacortical fixation for bone–patellar tendon–bone grafts for the tibial side.
Insert the adjustable loop into both the femoral and tibial adjustable juxtacortical fixation for bone–patellar tendon–bone grafts.
Load the free strands from both adjustable juxtacortical fixation for bone–patellar tendon–bone grafts through the AL and close the system.
Graft preparation
Prepare a 4 times' folded ST graft.
Use a Vicryl No. 2 suture in a continuous suture fashion.
Perform 2 security reinforcement knots with nonabsorbable sutures at each side of the graft.
Wrap the AL around the 4 times' folded ST graft and apply mild tension on the seatbelt construct.

AL, adjustable loop; ST, semitendinosus; XL, extra-large.

After the ST tendon is harvested and on the surgical table, the graft tibial end must be inserted in the tibial loop adjustable juxtacortical fixation for bone–patellar tendon–bone grafts and fixed temporarily with a clamp. Then, the ST is introduced through the femoral loop and folded 4 times over itself. A continuous Vicryl No. 2 suture (Ethicon, Somerville, NJ) is applied longitudinally to progressively tension and lock the graft and finally is tied at the tibial side. Two independent, high-resistance, nonabsorbable locking sutures are used at the femoral side at 10 mm and 20 mm to secure the graft. Two more independent nonabsorbable sutures are used to secure the tibial side of the graft at 5 and 15 mm. The 4 locking nonabsorbable sutures will remain inside the femoral and tibial tunnels.

Once the graft is well fixed and secured, the adjustable loop must be put around the graft and tensioned over it as an SB (Fig 5). The tension applied to the loop is submaximal, so that the ST still remains under greater tension than the loop. Now, the SB ACL graft is ready to be passed through the tibial and femoral tunnels.

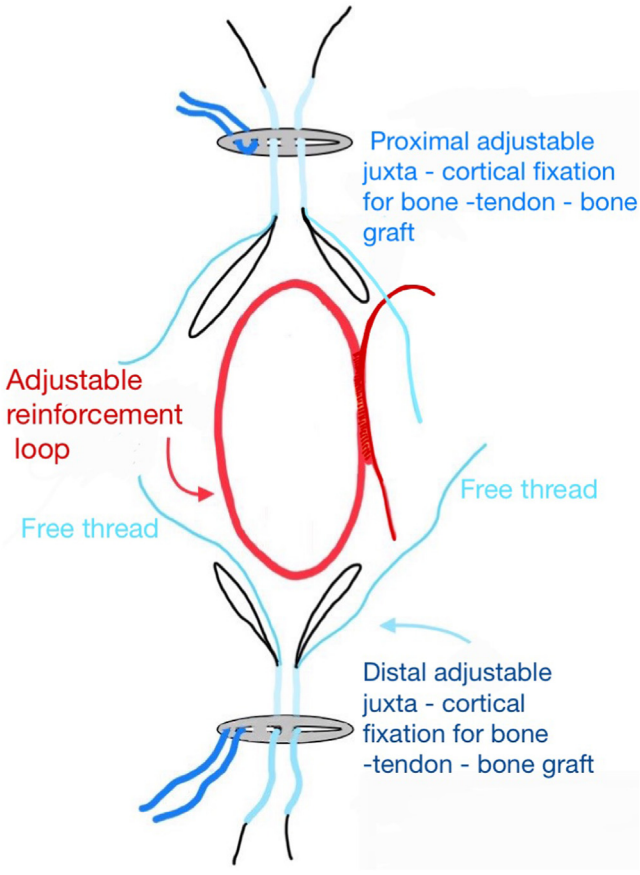

Fig 1. Each proximal adjustable juxtacortical fixation device has 2 free blue threads, ready to engage the red adjustable reinforcement loop, which is between them in the graft preparation table.

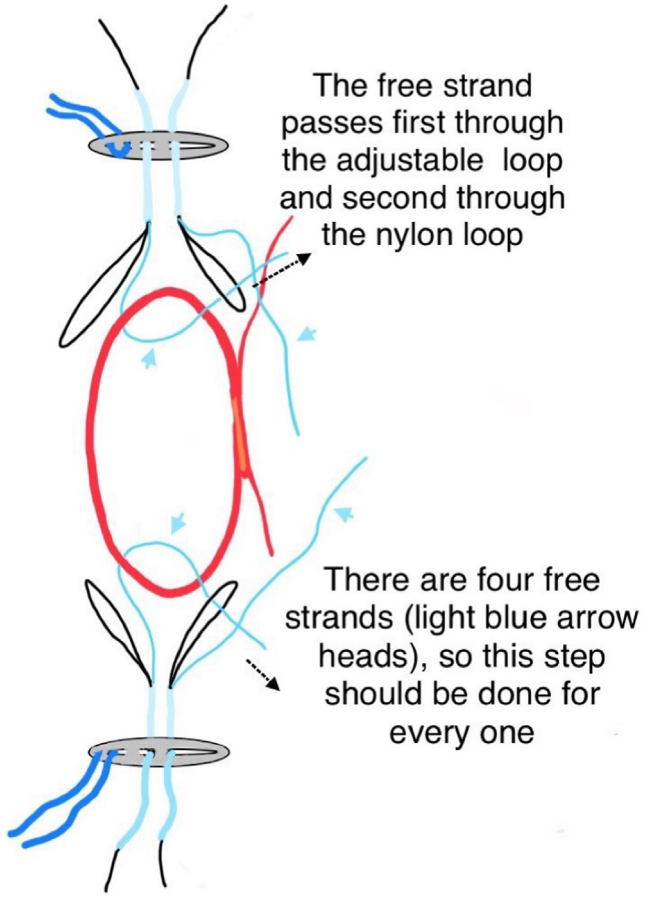

Fig 2. Each adjustable juxtacortical fixation device free thread should go through the red adjustable reinforcement loop (seatbelt) to reach for the opposite black retrieving nylon suture. The black nylon retrieving suture will then allow to pass the blue thread through the suture sleeve and the suspensory device.

Drilling Tunnels

The femoral tunnel is drilled with an inside-out technique and the tibial tunnel is drilled with an outside-in technique using an ACL guide with 65° of angulation.

Graft Passage and Fixation

The graft is introduced from the caudal to cranial direction, through the tibial tunnel to the femo ral tunnel with a traction suture. Then, the graft is fixed with both femoral and tibial suspensory systems.

Postoperative Rehabilitation

A routine ACL rehabilitation program is carried out. Crutches and an articulated brace are recommended for 6 weeks.

Discussion

ACL tear is a major injury that can lead to chronic pain, recurrent instability, meniscal tears, and

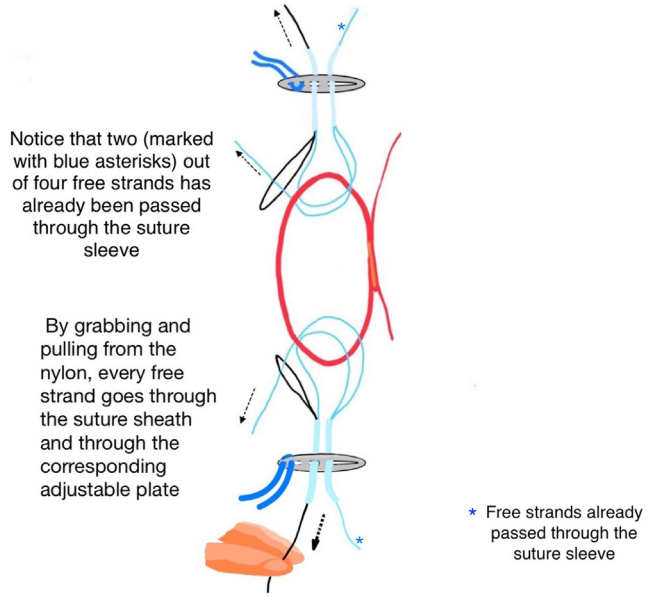

Fig 3. The opposite free blue strands form each suspensory device must be passed as well through the red adjustable reinforcement loop (seatbelt) to reach for the opposite black nylon retrieving suture. The opposite black nylon retrieving suture will then allow to pass the blue thread through the suture sleeve and suspensory device by applying gentle traction .

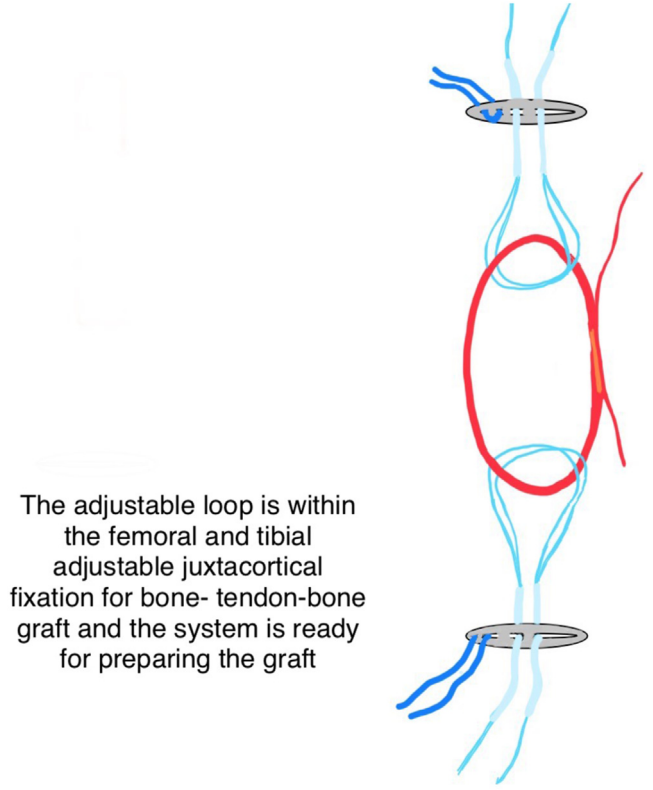

Fig 4. This creates a double loop through the proximal and distal ends of the seatbelt, once the 4 strands have been recovered off the adjustable suspensory devices.

Table 2. Pearls and Pitfalls

Pearls	Pitfalls
Insert the loop into the adjustable juxtacortical fixation for bone–patellar tendon–bone grafts before folding the graft.	Once the AL is inside the bone–patellar tendon–bone, avoid closing it less than 10 cm long, to be able to prepare the graft and then put it around the 7-cm ST graft and then easily tensioning the seatbelt around the graft.
Maintain the AL untensioned into the construct, keeping it aside so that the ST graft is prepared easily.	Do not overtension the AL around the graft. The reinforcement should have some tension, acting and becoming more tensioned when the knee suffers a sport accident.
Once the ST graft is sutured and secured, the AL is tensioned around.	

AL, adjustable loop; ST, semitendinosus.

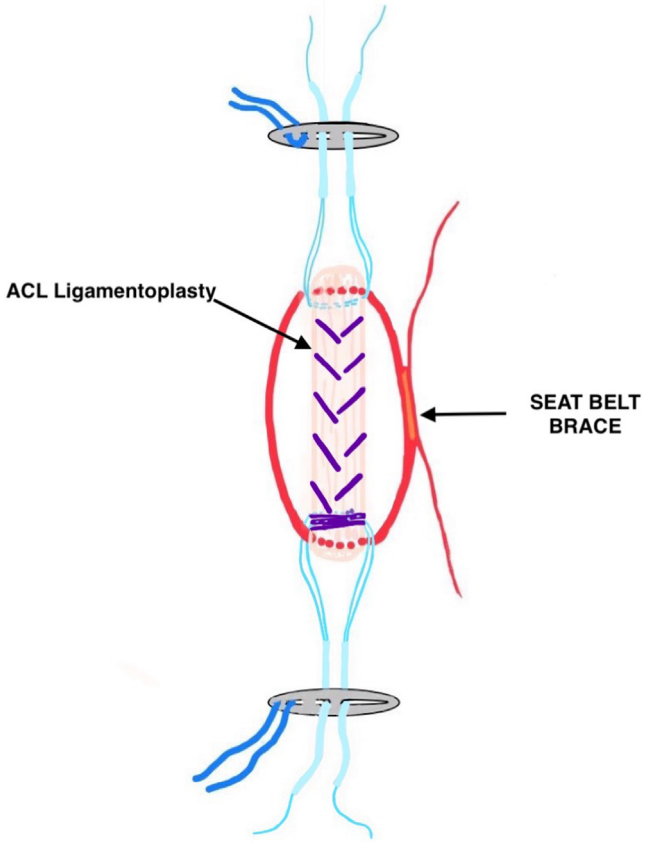

Fig 5. The graft is 4 times folded around the suspension loops, and fixed with a Vicryl No. 2 continuous suture to unify the fibers after applying progressive tension to the graft. The reinforcement seatbelt loop is then tightened around the graft and highlighted with a red color in this image.

degenerative changes in the knee. Arthroscopic reconstruction of damaged ligament with autologous graft remains the gold standard. Among the complications, graft rupture is one of the most significant, not only for the patient but for the surgeon. The proportion of rupture of the graft can range from 0 to 25%, depending on the published series.[6]

According to the magnitude of the problem, in recent years, some reinforcement techniques have been developed that aim at avoiding such a complication. Ligament augmentation with suture seeks a statistical load-share between the synthetic graft and the graft. There are biomechanical studies demonstrating that ligament augmentation with suture increases the resistance of ligament repair. Matava et al.[7] concluded in their biomechanical study conducted on young pigs as specimens that the use of independent suture tape to reinforce ACL reconstructions, in this case with bone–patellar tendon–bone graft from humans, was associated with an increase in stiffness of 104% and 54% of the load until failure, compared with cases that did not use IB.

Some studies have attempted to assess clinically the effect of ACL repair with suture augmentation. Wilson et al.[8] published a systematic review including studies reporting outcomes of arthroscopic primary repair of proximal ACL tears augmented with IB from 2014 to 2021. Finally, 9 studies were included, with a total of 347 patients and a mean minimum follow-up of 2 years. The

Table 3. Advantages and Disadvantages

Advantages	Disadvantages
The use of an adjustable device as internal brace permits a more exact and adapted tension almost equal or as desired, with respect to the ligament reconstruction tension.	Assembly of the whole construct system could be technically challenging.
This is a bone-preservation technique; lesser potential weakness to the distal end of the ACL graft is caused by the augmentation passage toward tibial fixation.	There is some concern about stress forces caused by the reinforcement brace onto ligamentous construct.
Mechanically, 3 loop devices attached in series produce a chain effect, with a load-sharing that guarantees the strength of the reinforcement system	The addition of the intra-articular adjustable loop may create concern for postoperative effusions.
	Use of suture augmentation adds higher costs compared with conventional ACLR methods.

ACL, anterior cruciate ligament; ACLR, anterior cruciate ligament reconstruction.

Table 4. Risks and Limitations

Risks	Limitations
Apply more tension to the SB loop IB than to the ligamentoplasty.	The use of the SB loop IB at the less isometric femoral footprint.
Overstretching the SB loop IB could cause damage to the ligamentoplasty.	

IB, internal brace; SB, seatbelt.

results were that this technique is safe for repairs of acute proximal ACL tears with a mean revision rate of 10.4%.

Many ways of performing the IB are described. Buranapuntaruk et al.[3] propose an arthroscopic all-inside ACL reconstruction using the shortening strands of a flexible femoral suspensory button as reinforcement. Zhao et al.[9] describe a technique where IB is done with a 12 Ultrabraid suture connected to 2 Endobuttons, while a primary repair of a proximal ACL tear preserving AM and PM bundles is practiced.

With the use of FiberTape IB, the ultra-high molecular weight polyethylene tape stabilizes the graft during healing phase. The tape is fixed usually to a femoral cortical button, whereas a tibial button or an anchor could be used for distal fixation.

Under normal conditions, the ACL graft is the one that supports all the tension during joint function. In case of SB ACL reconstruction, when there is a sport accident with anterior translation mechanism of the tibia, the graft is distended first. When this tension is also transmitted to the reinforcement, then it stops the graft distension, just as a SB would do when a passenger moves forward by inertia. From then on, load sharing is theoretically produced between the graft and the reinforcement, with the consequent protection of the graft.

Mechanically, 3 loop devices attached in series produce a chain effect, with a load-sharing that guarantees the strength of the reinforcement system. We think the SB loop configuration is resistant, like a chain system. The employment of a loop-adjustable device such as IB permits a more exact and adapted tension almost equal or as desired, with respect to the ligament reconstruction tension, that is established before graft fixation (Table 3). Thus, joint constriction caused by the reinforcement fixation as final step, like described in other techniques, is not possible. As the reinforcement loop goes between 2 adjustable loop devices and is not fixed to any cortical bone, no further tunnels need to be drilled through tibia or femur.

However, biomechanically speaking, we believe that this loop configuration should be used at the more isometric femoral footprint, which is the anteromedial femoral insertion.[10]

One limitation of this technique that should be further investigated is the use of the SB loop IB at the less isometric femoral footprint (Table 4). However, there is some concern about stress forces caused by the reinforcement brace onto ligamentous construct that should be further investigated. In addition, biomechanical studies should be performed to assess the resistance and ultimate load to failure of the new SB loop IB configuration, to finally benefit our athletes from a reduced graft re-rupture rate.

Disclosures

All authors (M.A.G., A.V.O., C.H.A., I.M.A., C.A.S., G.T.D.) declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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