

# A New Algorithm for Extra-Articular Reinforcement in ACL Injury Based on Rotational Instability

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**Background:** The results of surgical reconstructions of the anterior cruciate ligament (ACL) are improving with the association of extra-articular reinforcements, such as anterolateral ligament reconstruction and Lemaire tenodesis. However, ACL injury can occur through various mechanisms, and when there are valgus and external rotation of the tibia, anteromedial rotational instability (AMRI) may develop. Articular reinforcement in the anteromedial quadrant, in the topography of the anterior oblique ligament (AOL), can be an important tool for patients with ACL injury and external rotation instability.

**Indications:** The physical examination under anesthesia in patients undergoing ACL reconstruction who are candidates for extra-articular reinforcements provides important information about rotational instability. Patients with instability in external rotation may benefit from anteromedial reinforcement in the AOL's topography.

**Technique Description:** We propose an algorithm to be followed in patients with ACL injury and indication for extra-articular reinforcement. Patients with a positive pivot shift, indicating internal rotation instability of the knee, should undergo anterolateral reinforcements, as well as those patients with joint hyperlaxity. The algorithm suggests performing the anterior drawer in external rotation (ADER) test. When positive in isolation, anteromedial reinforcement is indicated. When the physical examination shows both positive ADER and pivot shift, both medial and lateral extra-articular reinforcement could be performed.

**Results:** This new type of extra-articular reinforcement, in the AOL's topography, appears to be an important tool for improving surgical outcomes in ACL reconstructions. AMRI is a risk factor for central pivot reconstruction failure and should be investigated and treated, as proposed by the algorithm.

**Conclusions:** Clinical examination of the ACL-injured knee, preferably under anesthesia, should include internal rotational and external rotational examination (pivot-shift and ADER tests). AMRI, when detected, should be treated, and the AOL reconstruction seems to be a good alternative. We propose a new algorithm based on rotational instability to make our extra-articular reinforcement in ACL patients.

**Patient Consent Disclosure Statement:** The author(s) attests that consent has been obtained from any patient(s) appearing in this publication. If the individual may be identifiable, the author(s) has included a statement of release or other written form of approval from the patient(s) with this submission for publication.

**Keywords:** knee; ACL; knee instability; knee injury; rotational instability

## VIDEO TRANSCRIPT

Here is the presentation of a new algorithm to treat isolated anterior cruciate ligament (ACL) injuries based on rotatory instability tests under anesthesia. My name is Pedro Baches Jorge. Thank you to my coauthors Luiz Gabriel Guglielmetti, Camilo Helito, Sergio Canuto, Vitor Barion de Pádua, and Diego Escudeiro.

This is our disclosure: None of the authors have any relationships to disclose with either companies or products listed in this presentation.

## BACKGROUND

ACL injuries continue to increase in prevalence, even though we know more and more about them and their prevention.<sup>4</sup> In the past 10 years, the rate of injury has gone from 10 to 18 per 100,000 women per year and 22 to 25 per 100,000 men per year.<sup>4</sup> ACL injury in professional athletes is also not on the decline. Furthermore, the return to the same preinjury level is relatively low, and the rates of rupture and revision surgeries are relatively high.<sup>1</sup>

Current literature shows some alarming data and raises an alert. Our results may not be as good as we imagined. Studies demonstrate high rates of revision surgeries, with more than 15% in the first 2 years in professional male athletes.<sup>1</sup>



After a 2013 study describing the anterolateral ligament (ALL)<sup>3</sup> was published, extra-articular reinforcements and reconstructions began to gain importance as adjuvants to ACL reconstruction. Returning to the study of the knee peripheral anatomy opened space for new surgeries, always aiming to obtain better results in central pivot reconstructions.

The results that emerge from large comparative series seem encouraging. The extra-articular reinforcement in the topography of the ALL is a potential game changer. The rerupture rates are lower when compared to those of patients undergoing simple ACL reconstructions, using both hamstrings and the patellar tendon (bone-patellar tendon-bone [B-PT-B]).<sup>13</sup> In this study, the ACL reconstruction associated with the ALL reconstruction group had 2.5 times less rupture than the control group, which underwent simple reconstruction with B-PT-B and 3.2 times less rupture than the group that underwent simple reconstruction with the use of hamstrings.<sup>13</sup>

Extra-articular reinforcement with the reconstruction of the ALL protects the ACL graft, helping to control tibial internal rotation, demonstrated by a positive pivot shift. The ligament participates secondarily in controlling the articular varus and tibial anteriorization.

We know that different trauma mechanisms and sprain directions can lead to ACL injury. More often, the combination of a valgus knee with external rotation of the leg leads to ligament rupture.<sup>4</sup> Certainly, subsequent rotational instability will be directly related to the original trauma mechanism. Anyone who tears the ACL in external rotation will certainly develop rotational instability in external rotation.

Therefore, is the ALL the answer for all cases?

Anteromedial rotational instability (AMRI), described by Slocum and Larson<sup>12</sup> in 1968, may arise from valgus and external rotational trauma.<sup>11</sup>

If left undiagnosed, it is an ACL failure factor,<sup>11</sup> but unfortunately, knee surgeons do not routinely remember it.<sup>2</sup>

## INDICATIONS

To verify the existence of AMRI, there is the anterior drawer in external rotation (ADER) test, also described by Slocum and Larson<sup>12</sup> in 1968.

The test is best performed with the knee at 90° of flexion with the foot held in 15° of external rotation. The ADER test is positive if an anterior displacement of the tibia on the femur is noted in the described position.<sup>2</sup>

In 2022, Jorge et al<sup>8</sup> published research on the anatomic study of the knee medial compartment, focusing on the

anteromedial region. Their study describes a peripheral ligament, analogous to the ALL, on the opposite side of it. This ligament, called the anterior oblique ligament (AOL), is in front of the superficial medial collateral ligament (sMCL), as seen in these 3 images.

In 2024, a complete series of dissections was published, where the AOL underwent qualitative, quantitative, and histologic analysis.<sup>10</sup> This series also described for the first time the medial cross, the group of ligaments that stabilize the medial region of the knee. It consists of the superficial and deep medial collateral ligaments, the posterior oblique ligament (POL), and the AOL.

In the first picture, it is possible to identify the medial cross. The blue pins indicate the medial epicondyle and the sMCL insertion on the tibia. In green are both insertions of the oblique ligaments, anterior and posterior, which are identified by direct visualization and palpation. The orange pin shows the insertion of the POL on the semi-membranosus tendon.

When the tibia is rotated in both directions, you can see the function of the medial cross. During internal rotation, the POL becomes tense. During external rotation, the AOL becomes tense.

The author published the theory of tibial quadrants, which describes the knee rotational control provided by the peripheral ligaments, divided according to their locations in the 4 tibial quadrants.<sup>8</sup> The AOL in the anteromedial quadrant would control tibial external rotation. In other words, it would control AMRI.

For patients with ACL injuries, positive ADER, and/or mild valgus instability with a negative pivot shift, Jorge et al<sup>9</sup> described ACL reconstruction associated with AOL reconstruction. This surgery can be performed using the hamstrings alone or combined with the peroneus longus tendon anterior half.

The hamstrings and the peroneus longus anterior half were used in this case. The graft's longest portion is located in the tibial tunnel and is used for AOL reconstruction. After fixing the ACL with 2 screws, the AOL returns to the anterior portion of the medial epicondyle and is fixed there with the knee in full extension.<sup>9</sup>

It is possible to reconstruct the ACL and AOL using a suspensory fixation mechanism like an adjustable button.

The medial femoral tunnel for the AOL insertion is identified by fluoroscopy visualization, and the final fixation must be performed with the limb in full extension and neutral rotation.

In this surgery, we can see the graft prepared, its passage through the ACL tunnels, and the final positioning of the AOL.

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Submitted March 6, 2024; accepted June 20, 2024.

The authors declared that they have no conflicts of interest in the authorship and publication of this contribution. AOSM checks author disclosures against the Open Payments Database (OPD). AOSM has not conducted an independent investigation on the OPD and disclaims any liability or responsibility relating thereto.

The purpose is to revisit the knee rotational stability under anesthesia in patients with ACL lesions using the pivot-shift and ADER tests, as well as propose a new algorithm for extra-articular procedures combined with the ACL reconstruction.

## TECHNIQUE DESCRIPTION

This is the suggested algorithm for extra-articular reinforcement during ACL reconstruction. It is important to remember that the final decision is based on the physical examination under anesthesia compared with the healthy knee when possible.

In patients with internal rotation instability, positive pivot shift, and absence of external rotation instability (negative ADER test), extra-articular reinforcement in the anterolateral quadrant is suggested, like ALL reconstruction or Lemaire's tenodesis.

In those with a positive pivot shift associated with external rotational instability (ADER test) and/or mild valgus instability when compared to the contralateral limb, reinforcement in both anterior quadrants, lateral and medial, is suggested.

In this case, under anesthesia, there is a positive pivot shift associated with mild valgus instability.

The option is to assemble the graft for ACL reconstruction using the outside-in technique and fixation with 2 interference screws, reconstruction of the ALL as recommended by Helito et al,<sup>5,7</sup> and reconstruction of the AOL as recommended by Jorge et al.<sup>9</sup>

In patients with a negative pivot shift and instability in external rotation with a positive ADER test and/or mild valgus instability compared to the contralateral limb, we recommend ACL reconstruction associated with reinforcement in the anteromedial compartment through AOL reconstruction.<sup>9</sup>

Physical examination is performed on a patient under anesthesia with AMRI with negative pivot shift and positive ADER test; a patient with positive Lachman, negative pivot shift, and positive ADER test; a patient with positive Lachman, negative pivot shift, and positive ADER test; and a patient with positive Lachman, negative pivot shift, and mild valgus instability.

In patients with a negative pivot shift, negative ADER test, and joint hyperlaxity, ACL reconstruction is suggested to be associated with anterolateral compartment reinforcement, following what is recommended in the literature on cases with knee hyperextension.<sup>6</sup>

Finally, in cases where there is no rotational instability in anesthetized patients, the question remains as to which reinforcement to perform. Even without rotational instability, the anterolateral extra-articular reinforcement proves effective, protecting the graft in central pivot reconstruction and reducing rerupture rates. In other words, the reconstruction of the ALL is recommended. However, if there is knowledge about the trauma mechanism, it is suggested to reinforce in the sprain direction. Something to consider is the following: if trauma in external rotation is more prevalent,<sup>4</sup> would not reinforcement with the AOL

be a safe approach in these cases? Perhaps, but the evidence is still limited for us to state with certainty.

## DISCUSSION

**Surgical considerations:** For ALL reconstruction associated with ACL reconstruction, the hamstrings can be used, associated or not to the peroneus longus tendon anterior half. For AOL reconstruction, the same graft choice can be made. For AOL reconstruction, the femoral tunnel position is critical so that an x-ray may be used. The postoperative protocol does not change.

**Take-home messages:** The results of our ACL reconstructions can and should be improved. The ACL and ALL reconstructions seem to be a game changer, improving internal rotation control. But the trauma mechanism certainly predicts future rotational instability, and external rotation is the most prevalent.

Clinical examination of the ACL-injured knee, preferably under anesthesia, should include internal rotational and external rotational examinations (pivot-shift and ADER tests). AMRI, when detected, should be treated, and AOL reconstruction seems to be a good alternative.

We propose a new algorithm based on rotational instability to make our extra-articular reinforcement in patients with ACL injuries. Think about extra-articular reconstruction is also thinking about medial reconstruction.

These are our references.

Thanks.

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