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Extra-articular Augmentation of Anterior Cruciate Ligament Reconstruction: The Monoloop Procedure

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Contents

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31.1 Introduction

Anterior cruciate ligament (ACL) injury is associated with symptomatic instability and increased risk of injury to the menisci and articular cartilage of the knee [1]. The aim of surgical intervention is to improve clinical symptoms, restore knee kinematics as best possible, and reduce the risk of further injury to the menisci and articular cartilage [2, 3]. Our ability to alter the natural history of the ACL-injured knee, in terms of the later degenerative change seen typically, remains unproven.

The techniques utilized to "normalize" excess translation and rotation/pivot in the ACL-injured knee have evolved over time, and there is ongoing debate as to the optimal technique to apply. This is due, in part, to the difficulty in replacing the unique anatomical structure and function of the native ACL, alongside limitations in our understanding of the role of potential concomitant injury to knee joint structures other than the ACL in pathological translational and pivot-shift phenomena [3–5]. However, an appropriately placed central graft appears effective in limiting translation in the sagittal plane, and it is generally accepted that placement of such a graft in an oblique plane provides a significant moment of resistance against the rotatory torque that occurs during the pivot shift. Whether the introduction of this single oblique central graft alone is sufficient to prevent instability in all patients is a matter of continued concern however. As many patients appear to have ongoing rotational instability

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following all-inside ACL surgery, it appears reasonable to consider historical literature that suggests optimal surgical restoration of knee stability in some cases needs simultaneous consideration of potentially unrecognized concomitant injury to structures at the periphery of the knee joint. Of specific concern is the role of capsular or ligamentous structures on the lateral side of the knee [6–10]. It has been repeatedly postulated that a combined intra-articular ACL reconstruction with extra-articular augmentation on the lateral side may be of benefit for some patients. Furthermore, Fu and others have extensively investigated the structure and function of the individual bundles of the ACL and the role that they play in both translational and rotational control of the knee [11]. The internal double-bundle concept has been very helpful in focusing our attention on anatomical factors in ACL reconstruction that may impact on outcomes following ACL surgery. It also highlights the limitations of traditional arthroscopic-alone-based techniques using an isolated central graft as the universal construct for all patients diagnosed with an ACL injury. We believe that, given the biomechanically short lever arm of centrally placed grafts, certain high-risk patients may warrant additional intervention to limit pathological rotation following what we recognize as an ACL injury.While we apply both single and double-bundle ACL reconstruction techniques in our practice, surgeons at our institution have also applied extra-articular augmentation in select cases for over 30 years [7]. We continue to believe it has a role to play in optimizing the outcome in many patients presenting with the primary finding of a ruptured ACL. In particular, we use this extra-articular augmentation in patients participating in activities with a high level of cutting or pivoting, patients with hyperlaxity or a pronounced pivot shift, and all cases of revision ACL reconstruction. Herein we describe our technique for a combined intra-articular ACL reconstruction with an extra-articular procedure we refer to as the monoloop technique. This technique is based on previously described forms of utilization of a section of the iliotibial band for extra-articular augmentation but in a refined procedure with limited potential for morbidity.

31.2 Surgical Technique

31.2.1 Setup, Examination Under Anesthesia, and Intra-articular Procedure

Regional anesthesia is used in all patients. Patients are set up on the operating table in a supine position with the table flat. Knee stability (translation and pivot) and range of motion are evaluated under anesthesia and recorded prior to arthroscopy. The knee is prepared and draped in a standard sterile fashion, and an Ioban dressing is applied to the entire surgical site. A tourniquet is used and inflated prior to surgery commencing. Routine knee arthroscopy is first performed and a note made of any intra-articular pathology. Management of any meniscal or cartilage lesions is performed before preparation and placement of an intra-articular ACL graft. We use an anteromedial approach with the knee in hyperflexion when creating our femoral tunnel (drilling from the standard anteromedial portal and viewing from the standard anterolateral portal). We typically use hamstring autografts with endobutton fixation on the femoral side. The intra-articular graft is passed and fixed on the femoral side prior to performing any extra-articular surgery on the lateral aspect of the knee. Fixation on the tibial side is performed with the use of both a post and an interference screw (BioRCI-HA, Smith & Nephew, Zaventem, Belgium) or soft tissue fixation staple (Smith & Nephew, Zaventem, Belgium) depending on surgeon preference. This tibial fixation is performed after completion of the extra-articular augmentation (Fig. 31.1).

31.2.2 Extra-articular Skin Incision and Preparation of the Graft

For the extra-articular augmentation procedure, the knee is flexed at 60° (Fig. 31.2a). Gerdy's tubercle and the iliotibial band (ITB) are palpated and marked. An incision of approximately 6 cm in length is made. This starts just proximal to Gerdy's tubercle and continues along the posterior 1/3 of the palpable ITB proximally (Fig. 31.2b). The sub-

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cutaneous tissues are then divided and elevated off the ITB from Gerdy's tubercle to approximately 14 cm proximally (Fig. 31.3a). This is possible through retraction and elevation of the incision edges. The posterior edge of the ITB is palpated, and a posterior line is incised in the ITB along the tensed portion in the posterior 1/3. This tensed portion of the ITB is readily palpated with the

Fig. 31.1 Key steps of monoloop procedure

1.	Routine arthroscopy + management of any meniscal/chondral lesions
2.	Intra-articular ACL reco nstruction - fixation femoral side only
3.	Preparation of monoloop extra-articular graft from ITB
4.	Routing of graft under LCL & under lateral intermuscular septum
5.	Fixation of monoloop graft with tibia in external rotation
6.	Fixation of intra-articular graft on tibial side

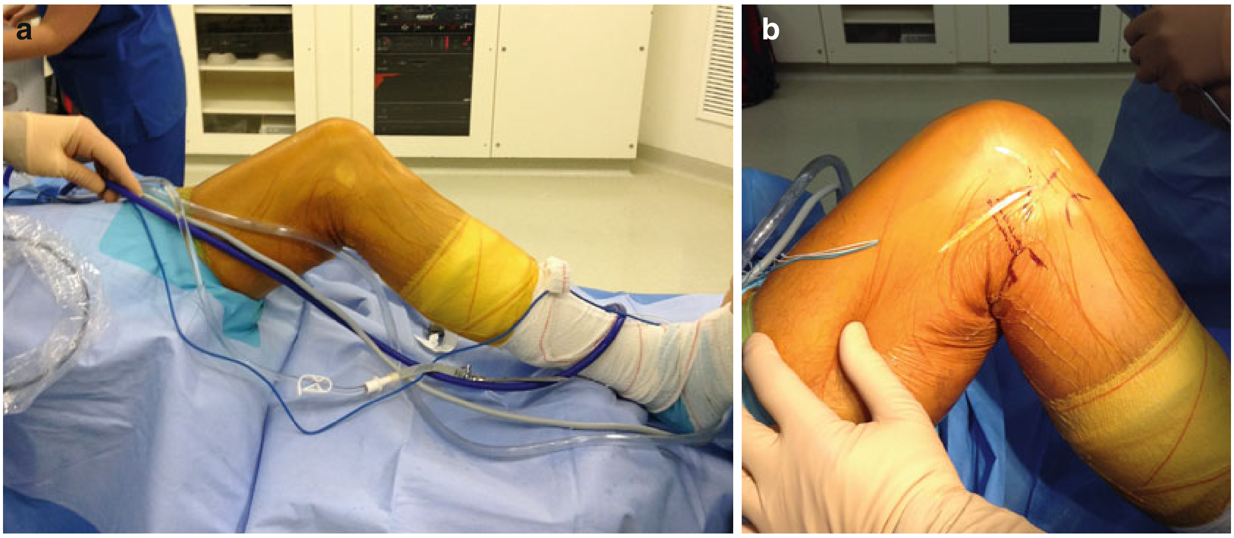

Fig. 31.2 (**a**) Setup and leg position. (**b**) Skin markings of major bony and soft tissue landmarks in addition to skin incision

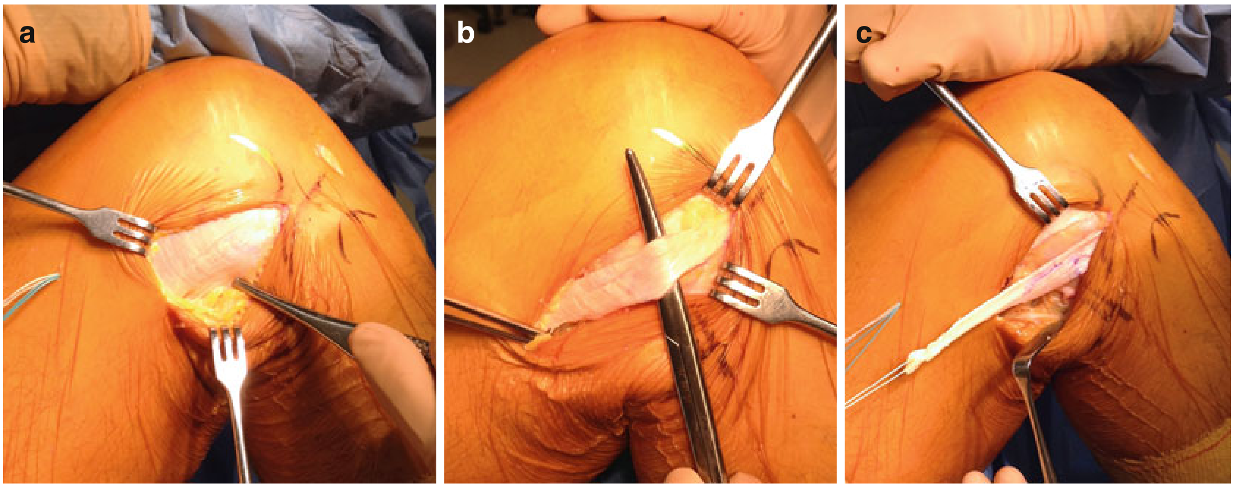

Fig. 31.3 (**a**) Iliotibial band (ITB) exposed and posterior aspect identified. (**b**) Strip of ITB, 1 cm wide and 12 cm in length (extending proximally from Gerdy's tubercle), is prepared. (**c**) Strip of ITB is released proximally and elevated. Leading suture placed in free end to aid passage of graft

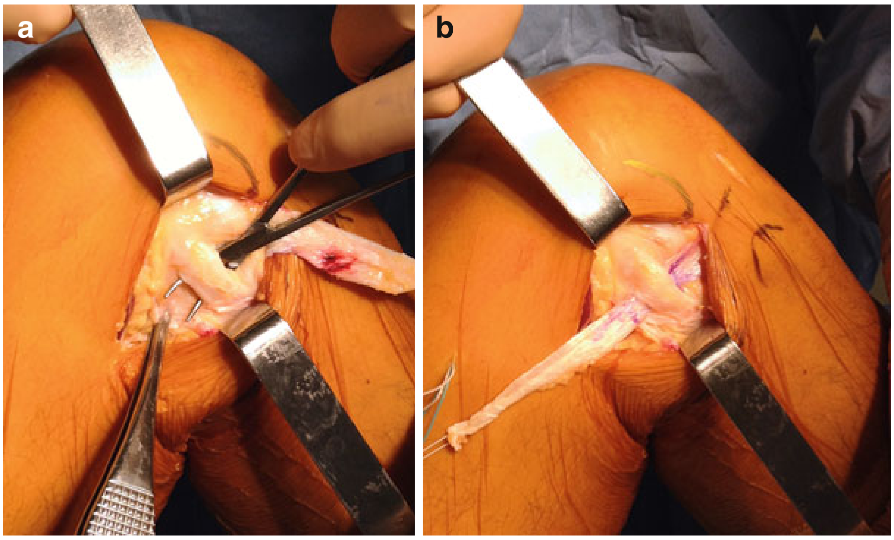

Fig. 31.4 (**a**) Lateral collateral ligament (LCL) is identified and a route to pass graft underneath is prepared. (**b**) ITB graft is passed under the LCL as shown

knee in 60° of flexion. With the addition of a second more anterior incision in the ITB, a strip of ITB of approximately 1 cm in width and 12 cm in length is elevated from the ITB (Fig. 31.3b). It is allowed to remain attached to Gerdy's tubercle but is freed up proximally (Fig. 31.3c).

31.2.3 Routing and Fixation of the Graft

The lateral collateral ligament is next identified. A 1 cm vertical incision is made on front and behind the LCL and the graft is routed under it (Fig. 31.4). The vastus lateralis muscle is then retracted, and the lateral intermuscular septum is identified on the distal femur (Fig. 31.5a). The fixation site is identified and cleared with the use of sharp dissection and electrocautery. Care must be taken not to disrupt the previously placed endobutton attached to the intra-articular graft as it should also lie in this area. The graft is then routed up under the lateral intermuscular septum, staying close to bone at the level of the septum (Fig. 31.5b, c). Depending on surgeon's preference, the monoloop graft is then laid down at a site of elevated cortical bone (sandwiched into the groove created) or simply laid against the native femur. In either event it is fixed in place with a soft tissue fixation staple (Fig. 31.6). It is important to keep the foot/tibia in external rotation at the time of tensioning and fixation of the graft. The intra-articular graft must also be kept under tension distally to prevent subluxation of the tibia and/or fixation of the extra-articular graft in a subluxed position. The leading end of the extra-articular graft (emerging from the staple) is then sutured back to the first part of the graft, which is ascending and passing under the staple. If the leading sutures from the previously placed endobutton are still in place, these may be tied over the graft.

31.2.4 Completion of Procedure

A drain is placed in the lateral wound, and the proximal half of the incision in the ITB is then closed depending on surgeon preference. The intra-articular graft is then fixed distally on the tibia. Rehabilitation follows routine ACL reconstruction guidelines, with the additional component of 2 weeks in a brace to keep the knee flexed to a minimum of 20° to protect the extra-articular graft.

31.3 Discussion

The optimal technique for soft tissue reconstruction in patients presenting with a ruptured ACL is unclear. The earliest efforts at ACL reconstruction focused on open extra-articular techniques

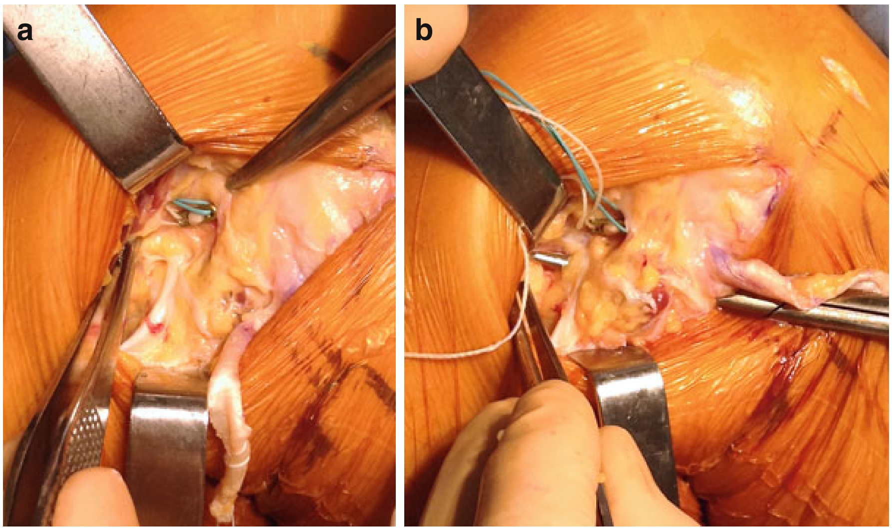

Fig. 31.5 (**a**) The vastus lateralis muscle is elevated, and the lateral intermuscular septum is identified and exposed. The previously placed cortical button should also be identified and protected. (**b**) A route for graft passage, first between capsule and lateral gastrocnemius, and then under the distal intermuscular septum while staying adjacent to bone, is prepared

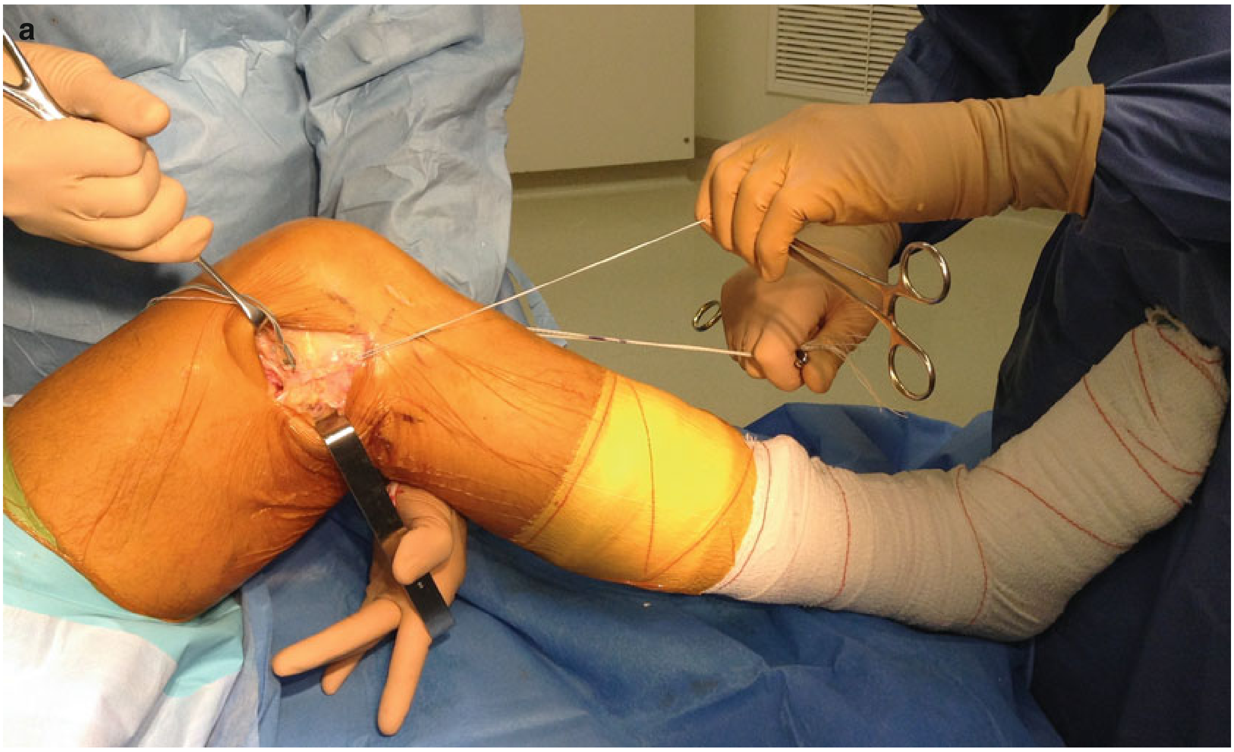

Fig. 31.6 (**a**) The graft is passed through the route prepared. The knee is then placed at 60° with the tibia in external rotation with tension placed on both intra- and extra-articular grafts for extra-articular fixation. (**b**) Soft tissue staple applied over graft which is held under tension. (**c**) Leading strand from cortical endobutton of intra-articular graft tied over extra-articular graft (optional). (**d**) Final appearance of extra-articular component prior to closure of wound

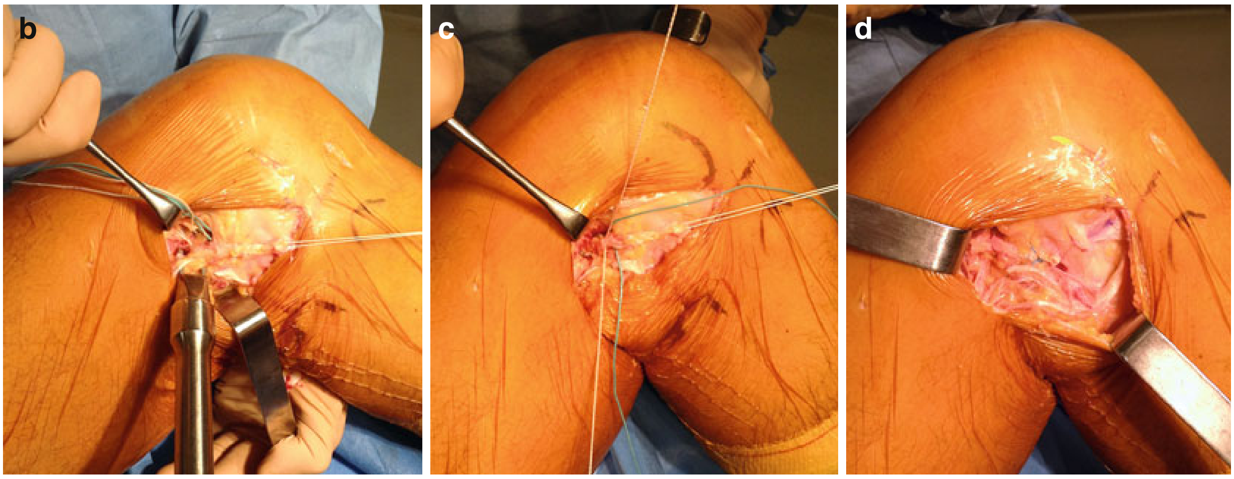

Fig. 31.6 (continued)

[6]. With arthroscopic advances came a movement in ACL surgery toward all-inside techniques. Most surgeons now apply a solely intra-articular technique, using either hamstring or patellar tendon grafts. Despite giving relatively consistent results, there is good evidence that current surgery does not restore normal kinematics and biomechanics, and in some cases does not prevent rotational instability. Although intra-articular techniques continue to be refined in an effort to prevent this, including the development of the double-bundle technique, it appears that there exists a subset of patients for whom an intra-articular procedure alone may be insufficient [6–10, 12].

The concept of the "slipping knee" has been recognized for nearly 100 years, and the term pivot shift has been in existence in the literature since 1972 [6]. Many investigators have linked this ACL injury phenomenon to concomitant injury to structures at the lateral aspect of the knee. The "pivot lesion" comprises characteristic bone bruising on the posterolateral tibial plateau and anterolateral femoral condyle that can be present on MRI scans of patients with acute ACL ruptures. Ségond has described an eponymous cortical tibial avulsion fracture which is seen on radiological imaging in many cases of ACL injury, noting that it occurs at the site of insertion of the middle third of the lateral capsular ligament [13]. Terry et al. demonstrated that during an injury that resulted in a clinically deficient ACL, 93 % of IT bands were also torn [9]. More recently, Neyret and others have revisited the anatomy of the lateral aspect of the knee and have helped to refine our understanding of what is now known as the anterolateral ligament of the knee [14–16]. It is possible to speculate that lateral structures may act as secondary restraints to the pivot-shift phenomenon, supplementing the primary restraint role of the ACL. Reconstruction of the ALL (and/or related structures) may have a clinical role to play in those patients in whom its structure or function is disrupted.

A number of techniques for extra-articular reconstruction of the ruptured ACL have been described previously. These include the Macintosh procedure, Losee's "sling and reef" operation, Ellison's distal ITT transfer, Andrews operation, and the Lemaire procedure [6]. While space limits the ability to detail the precise components of all techniques here, these procedures tend to also have in common the use of long strips of isolated ITT band with various forms of extended soft tissue routing. Femoral tunnels are also required in many of these procedures. The shortcomings of these techniques, where used in the isolated setting, have been highlighted previously, including their failure to restore stability [6]. Secondary degenerative changes in the lateral compartment were also seen, possibly because without concomitant intra-articular ACL reconstruction, the joint may be secured in a subluxed position with altered mechanics. Extended periods of immobilization, with associated complications, in addition to donor site morbidity and concerns about cosmesis have also been described. It should also be noted that some studies have reported limited benefit to extra-articular augmentation of intra-articular reconstruction where universally applied [6, 10]. Dodds et al recently provided an excellent review of combined intra- and extra-articular ACL reconstruction techniques [6]. While they note that some reports do demonstrate efficacy of the combined approach, it is difficult to draw any definite conclusions regarding superiority to isolated intra-articular reconstruction at the present time. Ultimately we remain limited in our knowledge due to a lack of understanding of concomitant lateral sided injury, small study sizes, heterogeneous groups of patients, and absence of randomization common in reported literature.

We reserve the application of monoloop extra-articular augmentation to what we consider are high-risk groups for recurrent instability following ACL injury. These primarily include those patients involved in a significant level of pivoting activity (e.g., soccer players, martial arts participants, etc.), patients with hyperlaxity or a very pronounced pivot shift, and those patients undergoing revision ACL surgery. As revision ACL surgery, and any subsequent revisions, have been demonstrated to be associated with increasing levels of cartilage pathology and also inferior outcomes, we believe that this subset of patients always warrant maximal support for the intra-articular reconstruction. Many of these patients do not have a clinically or radiologically demonstrable injury to the lateral structures, but it is possible that we do not yet have enough understanding of these structures, or of their examination and imaging, to define a threshold level of injury that warrants extra-articular reconstruction. For now, we believe the addition of an extra-articular augmentation remains warranted in the "high-risk" cases noted. The reconstruction of lateral structures should not be associated with excess lateral compartment chondral stress when used alongside intra-articular reconstruction. Furthermore, application of the minimally invasive technique described in this paper should limit concerns with cosmesis and morbidity.

Regarding the future, it has been proposed that if the anatomy and biomechanics of ACL injury and reconstruction can be fully established, it may be possible to devise a more scientific approach to ACL reconstruction, taking into account the specific structures which have been damaged, and to allow repair of these tissues in acute cases or their reconstruction at later time points [6]. Good quality clinical data will also be of benefit. We look forward to both contributing to and seeing such information in the literature.

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