Technical Note

Technique for Surgical Dissection and Histological Investigation of the Anterolateral Ligament in the Fetal Knee

Graeme P. Hopper, M.D., F.R.C.S. (Tr.&Orth.), Lampros Gousopoulos, M.D., Herve Ouanezar, M.D., Arnaud Walch, M.D., Frederique Dijoud, M.D., Thais Dutra Vieira, M.D., Camilo P. Helito, M.D., Ph.D., and Bertrand Sonnery-Cottet, M.D., Ph.D.

Abstract: There is growing evidence into the structure and function of the anterolateral ligament (ALL) of the knee. However, debate still exists about the anatomical characteristics, biomechanical role, and even the existence of the ALL, despite numerous cadaveric, biomechanical, and clinical studies. This article describes, with video illustration, the surgical dissection of the ALL in human fetal lower limbs, including determination of detailed anatomical and histological features of the ALL during fetal development. The ALL was clearly identified in dissected fetal knees, and histologic analysis shows well-organized, dense collagenous tissue fibers with elongated fibroblasts, consistent with the properties of a ligament.

Debate still exists regarding the anatomical characteristics and biomechanical role of the anterolateral ligament (ALL) of the knee, despite numerous cadaveric, biomechanical, and clinical studies. Since Claes et al.[1] described the anatomy of the ALL, several studies have demonstrated its presence and important biomechanical role,[2-7] although, other studies question the importance of the ALL, and some deny its existence.[8-11]

Helito et al.[7] dissected 20 human fetal knees and located the ALL in all of the specimens. Furthermore, the histologic sections showed well-organized, dense collagenous tissue fibers with elongated fibroblasts and a predominance of type 1 collagen, consistent with the ligamentous structure found in adults.[4] However, Sabzevari et al.[10] dissected 21 human fetal lower limbs and were unable to identify the presence of a distinct ligamentous structure.

This Technical Note describes surgical dissection of the ALL in human fetal knees and describes its histologic features (Video 1). We hypothesized that the ALL would exist during fetal development as a firm, independent ligamentous structure, as previously described.[1,2,6]

Surgical Technique (With Video Illustration)

Step 1: Iliotibial Band (ITB) Reflection

Two parallel curvilinear incisions are made. The first incision starts approximately 1.5 cm proximal to the joint line, posterior to the lateral epicondyle. This is extended distally, posterior to the fibular head, until approximately 1.5 cm distal to the joint line. The second incision starts approximately 1.5 cm proximal to the joint line, anterior to the lateral epicondyle. This is extended distally, medial to the Gerdy tubercle, until approximately 1.5 cm distal to the joint line. These

From NHS Lanarkshire University Hospitals, Glasgow, Scotland (G.P.H.); Centre Orthopédique Santy, FIFA Medical Centre of Excellence, Groupe Ramsay-Générale de Santé, Hopital Privé Jean Mermoz, Lyon, France (G.P.H., L.G., A.W., T.D.V., B.S.-C.); HMS Group FIFA Medical Center of Excellence Dubai, UAE (H.O.); Laboratoire d'Anatomopathologie, Centre de Biologie et Pathologie Est, Hospices Civils de Lyon, Bron, France (F.D.); and Knee Surgery Division, University of São Paulo, São Paulo, Brazil (C.P.H.).

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Address correspondence to Thais Dutra Vieira, M.D., Centre Orthopedique Santy, 24 Avenue Paul Santy, 69008, Lyon, France. E-mail: thaisdutravieira@hotmail.com

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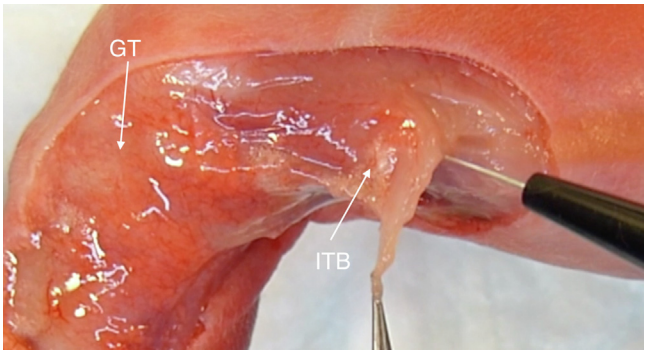

Fig 1. Lateral aspect of the knee. Visualization of the distal segment of the ITB after dissection and reflection of the subcutaneous tissues. (GT, Gerdy tubercle; ITB, iliotibial band.)

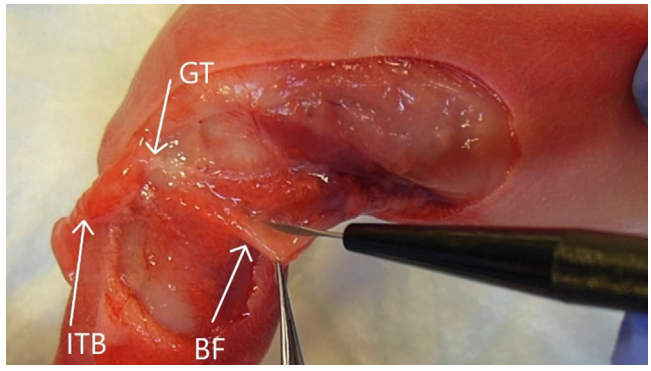

Fig 3. Lateral aspect of the knee. Posterior reflection of the distal insertion of the biceps femoris from the head of the fibula. (BF, biceps femoris; GT, Gerdy tubercle; ITB, iliotibial band.)

incisions are joined by a transverse incision proximally. Dissection and reflection of the subcutaneous tissues is then performed until the entire distal segment of the ITB is visualized (Fig 1).

A transverse incision is made in the ITB, approximately 1 cm proximal to the lateral epicondyle. The ITB is then carefully reflected distally. Meticulous dissection is crucial, as the deep fibers of the ITB are in close proximity to the fibers of the ALL. The ITB is reflected distally until its insertion onto the Gerdy tubercle then the underlying adipose tissue is gently removed (Fig 2).

Step 2: Posterior Capsulectomy

The distal insertion of the biceps femoris is then carefully reflected posteriorly from the head of the fibula (Fig 3). This allows easy identification of the lateral collateral ligament (LCL) as it inserts onto the head of the fibula and the overlying ALL, which originates posterior and proximal to the lateral epicondyle and extends distally to insert on the tibia between the Gerdy tubercle and head of the fibula in a fan-like fashion (Fig 4).

A portion of the capsule between the LCL and ALL is excised to clearly identify the posterior border of the ALL (Fig 5). The ALL overlaps the LCL therefore care must be taken during dissection to avoid disrupting the proximal fibers of the ALL.

Step 3: Anterior Capsulectomy

Once the posterior border of the ALL is well identified, the anterior capsule can then be excised to clearly identify the anterior border of the ALL (Fig 6). When this step is accomplished, the entire ALL is clearly visualized. The femoral insertion is slightly posterior and proximal to the lateral epicondyle.[3] The ALL then progresses in an oblique orientation anteriorly and distally. A small portion of the ALL fibers merge into

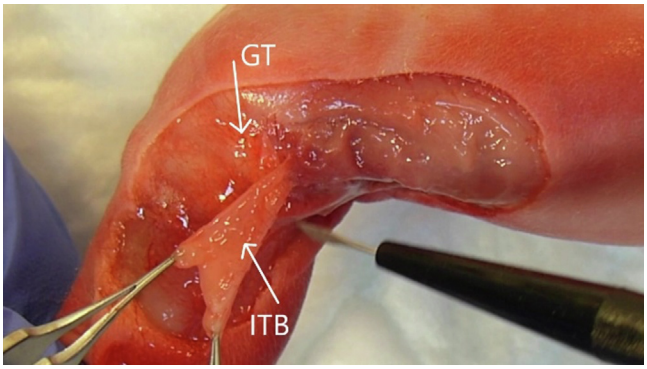

Fig 2. Lateral aspect of the knee. Distal reflection of the ITB until its insertion onto the GT, then removal of the underlying adipose tissue. (GT, Gerdy tubercle; ITB, iliotibial band.)

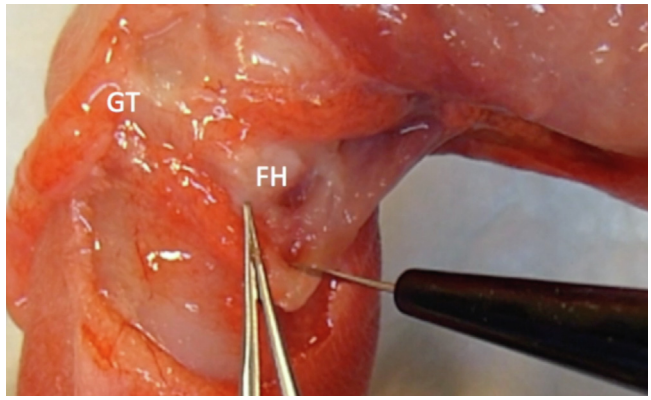

Fig 4. Lateral aspect of the knee. Identification of the FH. (FH, fibular head; GT, Gerdy tubercle.)

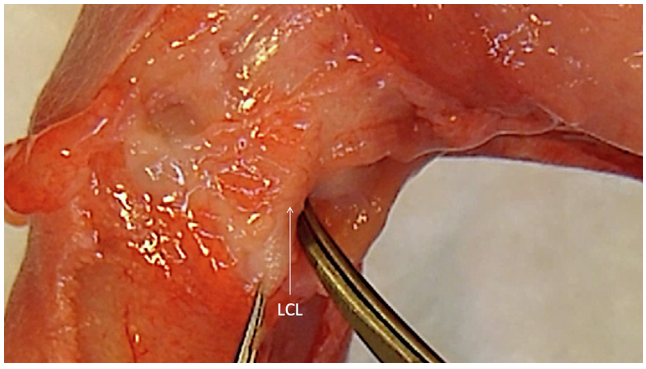

Fig 5. Lateral aspect of the knee. Identification of the posterior border of the ALL after excision of a portion of the capsule between the LCL and ALL. (ALL, anterolateral ligament; LCL, lateral collateral ligament.)

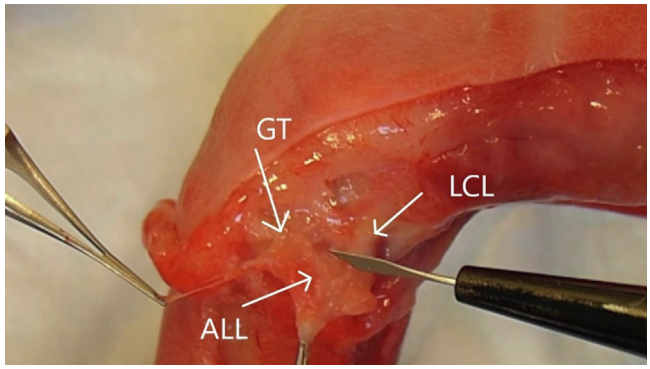

Fig 7. Lateral aspect of the knee. Distal insertion of the ALL in a fan-like fashion, with an anterior insertion just distal to the joint line and a posterior insertion slightly more distal. (ALL, anterolateral ligament; GT, Gerdy tubercle; LCL, lateral collateral ligament.)

the lateral meniscus. The ALL then inserts distally in a fan-like fashion, with an anterior insertion just distal to the joint line and a posterior insertion slightly more distal (Fig 7).

The ALL can be reflected from its femoral origin to delineate its anatomy further and clearly demonstrate its ligamentous structure in comparison to the LCL (Fig 8). Pearls and pitfalls of this dissection are outlined in Table 1.

Histologic Analysis

The ALL was found in all dissected knees. The samples were fixed in 4% buffered formalin (10% formalin 42%). They were cut at 4 microns (standard) and stained in hematoxylin phloxine saffron stain. The histologic sections of the ALL showed well-organized, dense collagenous tissue fibers with elongated fibroblasts and a predominance of type I collagen. The ALL exhibited a homogeneous hypovascular structure, whereas, in contrast, the knee joint capsule presented a more disorganized vascularized heterogeneous architecture with predominance of type II collagen.[12] According to the histologic analysis, it seems that the ALL possesses the histologic properties of a ligament (as it appears to present a comparable histological image with the IGHL[13] or the FCL[10]). From a histologic point of view, the ALL was clearly distinct from the capsular joint as an independent structure (Fig 9).

Discussion

This Technical Note describes, with video illustration, dissection of a ligamentous structure that is separate from the capsule in all fetal knees and is confirmed by histologic analysis. This ligament, the ALL of the knee,

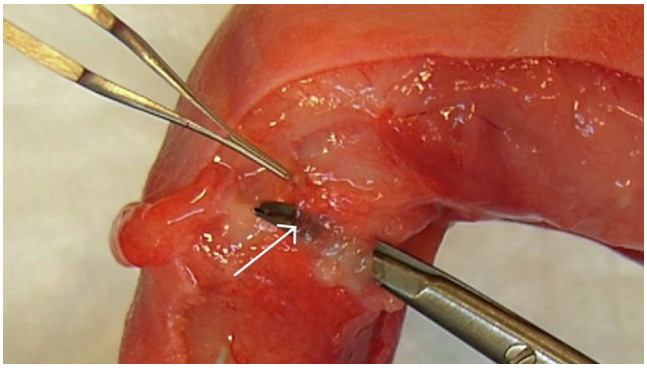

Fig 6. Lateral aspect of the knee. Identification of the anterior border of the ALL after excision of the anterior capsule. White arrow points to the anterior border of ALL. (ALL, anterolateral ligament.)

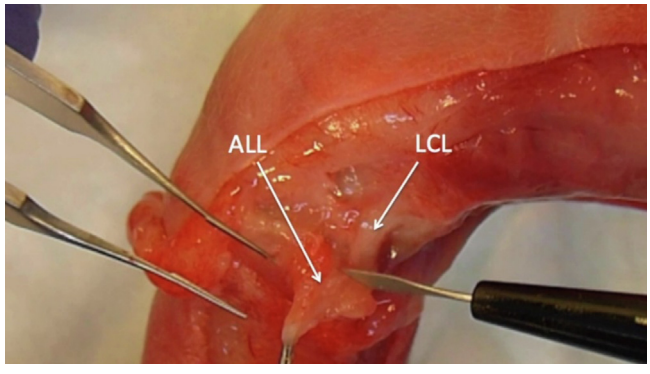

Fig 8. Lateral aspect of the knee. Reflection of the ALL from its femoral origin to delineate its anatomy further and clearly demonstrate its ligamentous structure in comparison to the LCL. (ALL, anterolateral ligament; LCL, lateral collateral ligament.)

Table 1. Pearls and Pitfalls of the Surgical Dissection of the ALL in the Fetal Knee

Steps	Pearls	Pitfalls
1. ITB reflection	Careful dissection is crucial, as the deep fibers of the ITB are in close proximity to the fibers of the ALL.	Failure to meticulously separate the layers could result in difficulty recognizing the ALL.
2. Posterior capsulectomy	Positioning the knee between 30 and 60° flexion and applying an internal rotation force can enhance visualization of the ALL.	If the ligament is not stretched, it may result in inadequate isolation of the ALL.
3. Anterior capsulectomy	Meticulous dissection can spare the attachment of the ALL to the lateral meniscus.	Failure to carefully dissect the anterior border of the ALL could result in difficulty recognizing the anterior tibial attachment.

ALL, anterolateral ligament; ITB, iliotibial band.

as previously described,[2,3,6] arises from its femoral insertion just proximal and posterior to the lateral epicondyle. It advances distally in an oblique direction, overlapping the LCL, to its tibial attachment. It inserts in a fan-like fashion between the Gerdy tubercle and the head of the fibula, just distal to the rim of the lateral tibia plateau.

The findings of this dissection of the ALL in fetal knees are comparable with the anatomical descriptions of the ALL previously defined in adults.[2,6] Furthermore, the anatomy is consistent with the dissection in fetal knees described by Helito et al.[4] Moreover, the histologic analysis is consistent with the findings of Helito et al.,[7] which is consistent with the ligamentous structure found in adults. Having a detailed knowledge of the anatomical characteristics of the ALL is essential to restore the normal knee kinematics when the ligament is injured.

Debate still exists regarding the role of the anterolateral structures of the knee in controlling rotatory laxity and their ability to share loads with an anterior cruciate ligament (ACL) graft.[14-16] Augmentation of ACL reconstructions with a lateral extra-articular procedure has been shown to decrease rotational laxity and residual pivot shift.[16,17] In addition, recent clinical studies have demonstrated that a combined ACL and anterolateral ligament reconstruction (ALLR) is associated with a significantly lower medial meniscal repair failure rate and ACL re-rupture rate when compared with those performed at the time of isolated ACL reconstruction.[18,19] This is likely a result of the re-establishment of the normal biomechanical properties of the knee, thereby restoring rotational stability and offering a protective effect on the ACL graft and the meniscal repairs.[18] ALLR should replicate not only the native anatomy but also the biomechanical properties and isometry of the ALL. Thus, the complications of an ALLR should be minimized.[20] In conclusion, the ALL was clearly identified in all dissected fetal knees, and histologic analysis

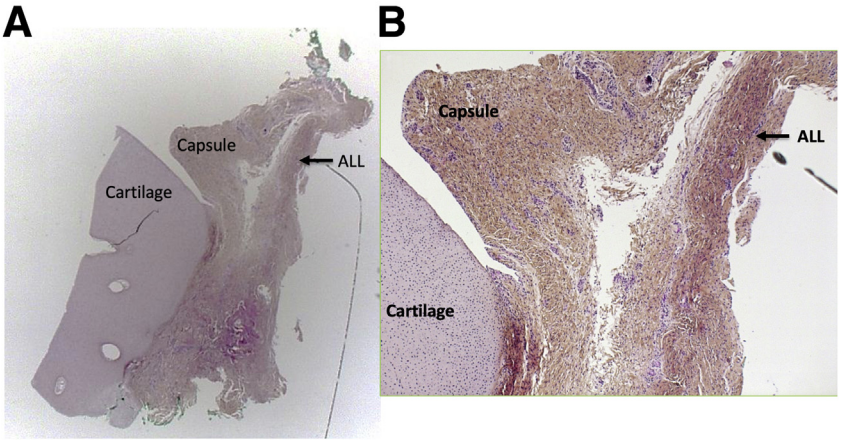

Fig 9. Histologic section. (A) Knee joint showing articular cartilage on the left with joint capsule to the right formed by collagen tissue with randomly orientated fibers. There is an area of increased density of the collagen fibers consistent with a ligamentous structure (ALL). (B) On the right side, there are thickened collagen fibers consistent with the formation of a ligamentous structure.

revealed characteristics consistent with a ligamentous structure, similar to the adult ALL.

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