The posterolateral corner (PCL) of the knee: Dynamic evaluation with high-resolution ultrasound (D-HRUS)

**Poster No.:** C-2205  
**Congress:** ECR 2010  
**Type:** Educational Exhibit  
**Topic:** Musculoskeletal - Joints  
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**Keywords:** knee, posterolateral corner, ultrasound  
**Keywords:** Musculoskeletal joint, Musculoskeletal system  
**DOI:** 10.1594/ecr2010/C-2205

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Learning objectives

The purpose of our educational exhibit is to describe the normal sonographic anatomy of the PLC of the knee integrated with dynamic manoeuvres.
Background

The PLC of the knee is a group of structures that together form a functional complex of muscles, tendons, capsule, and ligaments. The main function of this complex is to oppose the internal rotational and translational forces that act on the knee. It is also effective in stabilizing the joint against varus movements. The PLC of the knee can be evaluated by magnetic resonance imaging (MRI). However, due its complexity and its superficial location, PLC visualization can be suboptimal. In addition, MRI evaluation of PLC can be limited by the exam performed with the knee in extension. Finally, some PLC injuries are only highlighted under stress, a condition that can be hardly reproduced during a MRI scan. HRUS seems to be the ideal imaging technique to evaluate the PLC of the knee. In fact, its very superficial location is easily and effectively reached using a high-resolution broadband linear array transducer (up to 18 MHz). Then, HRUS has the great advantage to examine the knee during flexo-extension movements and under stress (e.g. with the patient standing on the floor), thus revealing small tears otherwise undetectable. Moreover, HRUS is cheaper and more readily available compared to MRI and can be used to perform an immediate comparative evaluation of the counterlateral knee. A number of previous studies both on cadavers and in living subjects described the sonographic appearance of normal anatomy of the PLC of the knee. However, none of them presents any dynamic image of such structures.
POPLITEUS MUSCLE AND TENDON Popliteus muscle and its tendon are the main dynamic stabilizers of the PLC of the knee. It takes origin proximally from the middle facet of the lateral surface of the lateral femoral condyle and inserts distally onto the posterior tibia. The tendon is intracapsular and runs behind the posterior wall of lateral meniscus where it gives some extensions. The function of the popliteus muscle is to rotate the femur on the tibia and assists the flexion of the leg upon the thigh.

POPLITEOFIBULAR LIGAMENT Popliteofibular ligament is the main static stabilizer of the PLC of the knee. Popliteofibular ligament has a significant role in preventing excessive posterior translation and varus angulation, and in restricting excessive primary and coupled external rotation. It is a ligamentous structure descending from the musculotendinous junction of the popliteus to the posterosuperior prominence of the fibular head, just adjacent to the insertion of the LCL. Half of this ligament is partially covered by the origin of the LCL. The arcuate ligament hides partially the PFL and it blends with it. In its distal two-thirds the orientation of the fibres of the popliteofibular ligament is nearly vertical and similar to that of the LCL. In its proximal one-third it fuse with the popliteal tendon and is orientated more obliquely.

LATERAL COLLATERAL LIGAMENT The LCL is a round ligament that lies beneath the tendon of the biceps femoris muscle and runs from the lateral epicondyle, anterior to the origin of the gastrocnemius muscle, to the fibular head where it blends with the biceps femoris tendon. The LCL lies just posterior to mid-axial point of the knee and is the primary restraint to varus stress in the knee. The LCL is not connected with the meniscal capsule but it is separated by a thin fat pad. The LCL is tight when the knee is extended and it becomes loose when flexion exceeds 30°.

BICEPS FEMORIS TENDON The biceps femoris tendon is a strong stabilizer of the PLC of the knee. The tendon inserts into the anterolateral side of the head of the fibula, and by a small slip into the lateral condyle of the tibia. At its insertion the tendon divides into two portions, which embrace the lateral collateral ligament of the knee-joint. From the posterior border of the tendon a thin expansion is given off to the fascia of the leg. Both heads of the biceps femoris perform knee flexion and help the extrarotation of the leg. LATERAL HEAD OF THE GASTROCNEMIUS Although the main function of gastrocnemius is plantar flexion, the lateral head acts as an important dynamic stabilizer of the PLC of the knee. The lateral head arises from the lower posterior surface of the femur above the lateral condyle, embedding also the fabella, when present. The tendon is very shorts and almost immediately it blends into the myotendineous junction.

FABELLOFIBULAR LIGAMENT The fabellofibular ligament inserts on the apex of fibular styloid process and ascends vertically to lateral head of gastrocnemius where it blends with posterior termination of oblique popliteal ligament. The fabellofibular ligament is found deep between biceps tendon and lateral head of gastrocnemius. The fabellofibular ligament alone reinforces capsule in 20% when arcuate ligament is missing. When fabella is large, fabellofibular ligament is large, but arcuate ligament is not usually present.
**ARCUATE LIGAMENT** The arcuate ligament is an extracapsular ligament of the PLC of the knee. It is usually Y-shaped, even though it can also be fan-shaped when fabella is missing. The main insertion is on the fibular head. From there, one arm runs over popliteus muscle and attaches on the posterior middle tibia. This arm could be missing when fabella is absent. The other arm blends with the proximal insertion of the lateral head of gastrocnemius on the lateral epicondyle of the femur.

**LATERAL GENICULATE ARTERY** This structure is not properly a part of the PLC of the knee. However, knowing its anatomy is fundamental when evaluating such region, as it serves as an important anatomical landmark. Arising from the popliteal artery, it runs inferolaterally around the knee. In the PLC, it runs deeply to the lateral collateral ligament and superficially to the popliteofibular ligament.
Fig. 0: Popliteus muscle and tendon. F=femur; T=tibia; LM=lateral meniscus; white arrows=popliteus tendon; yellow arrows=popliteus muscle; asterisk=anisotropy artifact that hinders the proximal enthesis of popliteus tendon.

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**Fig. 0:** Popliteofibular ligament. F=femur; T=tibia; LM=lateral meniscus; white arrows=popliteus tendon; yellow arrows=popliteus muscle; asterisk=anisotropy artifact that hinders the proximal enthesis of popliteus tendon.

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**Fig. 0:** Lateral collateral ligament. Extended field of view scan (EFOV) of the PLC of the knee. F=femur; T=tibia; LM=lateral meniscus; Fi=fibula; asterisk=popliteus tendon; white arrows=lateral collateral ligament.

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**Fig. 0:** Biceps femoris muscle and tendon. F=femur; T=tibia; LM=lateral meniscus; Fi=fibula; white arrows=biceps femoris tendon; yellow arrows=biceps femoris myotendineous junction.

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**Fig. 0:** Lateral head of the gastrocnemius. F=femur; white arrows=lateral head of gastrocnemius muscle; asterisk=tendon insertion.

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Fig. 0: Fabellofibular ligament. Fa=fabella; F=femur; Fi=fibula; white arrows=fabellofibular ligament.

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Fig. 0: Arcuate ligament. F=femur; T=tibia; Fi=fibula; white arrows=arcuate ligament; asterisk=lateral collateral ligament; yellow arrow=lateral geniculate artery.

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Fig. 0: Lateral geniculate artery. F=femur; PF=popliteofibular ligament; white arrows=lateral collateral ligament; asterisks=lateral geniculate artery.

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**Fig. 1:** Dynamic evaluation of popliteofibular ligament during slight flexion of the knee and internal rotation.

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**Fig. 2:** Dynamic evaluation of lateral collateral ligament during flexion of the knee and slight internal rotation.

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Fig. 3: Dynamic evaluation of biceps femoris during slight flexion of the knee and internal rotation.

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Conclusion

HRUS is effective in the depiction of normal anatomy of the PLC of the knee. The dynamic evaluation of PLC structures is effective to understand the complex mechanism of stabilization of such area. Further studies on patients with PLC instability are needed to establish the clinical role of dynamic HRUS in the evaluation of such area.
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