Current Concepts

Assessment and Augmentation of Symptomatic Anteromedial or Posterolateral Bundle Tears of the Anterior Cruciate Ligament

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Abstract: The anterior cruciate ligament (ACL) consists of 2 anatomic and functional bundles, the anteromedial (AM) and posterolateral (PL) bundle. Depending on the mechanism of injury, there are different injury patterns to the AM and PL bundles, demonstrating a wide spectrum of partial ACL tears. Clinical interest has recently focused on establishing pre- and intraoperative ways of assessing the different types of symptomatic partial ACL injuries in order to perform an individual ACL augmentation according to the specific injury pattern. Theoretically, sparing the intact parts of the ACL may increase vascularization and proprioception, may optimize the accuracy of the ACL reconstruction, and may result in better stability and improved clinical outcome for the patient. However, an isolated reconstruction of the AM or PL bundle is an advanced arthroscopic procedure that requires a precise pre- and intraoperative diagnostic assessment of the injury pattern, an exact arthroscopic knowledge of the anatomic insertion sites, a careful debridement, and bone tunnel placement while preserving the intact parts of the ACL. This article will present the concept of partial ACL tears and will describe the clinical, radiologic, and arthroscopic assessment and the arthroscopic technique of isolated AM or PL bundle augmentation. **Key Words:** Anatomic reconstruction—Anterior cruciate ligament—Anteromedial bundle—Augmentation—Double-bundle—Partial rupture—Posterolateral bundle.

The anterior cruciate ligament (ACL) consists of the anteromedial (AM) and posterolateral (PL) bundle (Fig 1) that already exists during the fetal period and are separated by a fine septum.[1-14] The center of the tibial AM insertion is in the anteromedial part of the ACL footprint lateral to the medial tibial spine and posterior to the anterior rim of the ACL stump and the transverse intermeniscal ligament. The center of the PL bundle is in the posterolateral part of the ACL anteromedial to the eminentia intercondylaris and the posterior root of the lateral meniscus in the area intercondylaris anterior. In 100° to 110° of knee flexion, the center of the femoral AM insertion is inferior to the "over the top" position and the center of the PL insertion is posterior to the shallow rim of the articular cartilage of the lateral femoral condyle.[2-10,12-14] The anteroposterior (AP) length of the tibial ACL insertion is an average of 14 to 17 mm (range, 9 to 20 mm), and the AP length of the femoral ACL insertion is an average of 15 to 18 mm with a smaller range (14 to 21 mm).[2-10,12-14] The average cross-sectional area of the AM insertion sites is 67 mm^2 on the tibia and 44 mm^2 on the femur, and for the PL insertion sites is 52 mm^2 and 40 mm^2, respectively.[14,15] The intra-articular length of the AM bundle is in the range of 28 to 38 mm whereas the shorter PL bundle is an average of 18 mm.[5,9]

According to their distinct insertions sites, each bundle contributes individually to the overall biome-

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The authors report no conflict of interest.

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0749-8063/08/2411-8226$34.00/0
doi:10.1016/j.arthro.2008.06.016

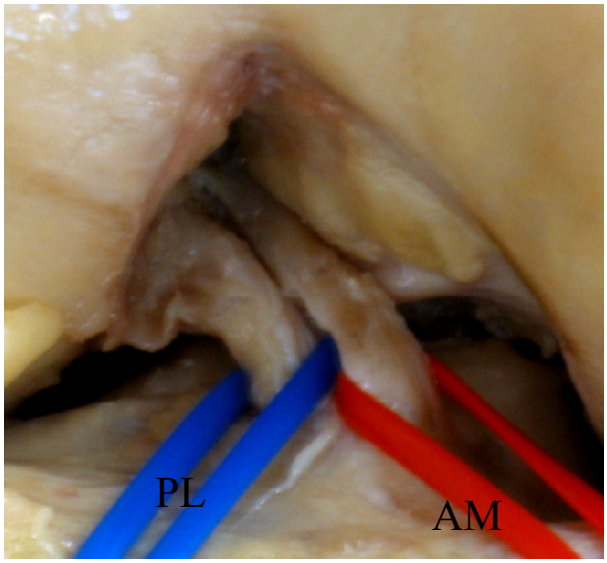

Figure 1. Right knee from a cadaveric specimen showing the anteromedial and posterolateral bundles.

chanical function of the ACL.[16-22] A previous study by Sakane et al.[20] investigated the specific role of each bundle for anterior stability. The authors showed that the AM bundle has relatively constant levels of in situ forces during knee flexion, whereas the PL bundle is more variable, with high in situ forces at 0°, 15°, and 30° of flexion, but rapidly decreasing thereafter. The AM but especially the PL bundle contribute to rotational stability of the knee in 0° to 30° of flexion, and both bundles contribute to anterior stability.[16-22]

Based on the anatomic and biomechanical double-bundle (DB) concept, recent research has focused on the diagnosis and treatment of symptomatic partial ACL tears with the use of individual arthroscopic augmentation.[1,23-30] Saving the intact parts of the ACL may have several advantages[31-34]—however, an AM or PL augmentation is an advanced arthroscopic procedure that requires a precise arthroscopic surgical technique.

This article will present the concept of partial ACL tears, and will describe the clinical, radiologic, and arthroscopic assessment and the arthroscopic technique of isolated AM or PL bundle augmentation.

METHODS

Injury Pattern of Isolated AM or PL Bundle Tears

Clinical observations of partial ACL tears show significant variations in the injury pattern of the AM and PL bundles. Depending on the injury mechanism, there is a wide range from asymptomatic to symptomatic elongation and rupture of 1 or 2 bundles.

A recent investigation by Zantop et al.[27] focused on the correlation between injury mechanism, as evaluated by patient reporting, and the injury pattern of the 2 ACL bundles, as evaluated arthroscopically. The authors interviewed 121 patients and showed that an AM bundle tear seems to involve a more explosive-type trauma to the knee, predominantly in the anterior direction, whereas an injury to the PL bundle might involve a less energetic pivoting injury with a predominantly rotational component. They reported a complete rupture of the AM and PL bundles in 75% of all assessed ACL injuries; 56% experienced an AM or PL bundle rupture at the same location, most frequently at the femoral insertion site, and in 44% the location of the tear was different for both bundles. The PL was elongated or intact in 12% of the patients, and the AM bundle could not be graded as intact or elongated in any patient.

Ochi et al.[26] reported a series of 169 patients with an ACL rupture. They found a partial tear of the ACL in 10% of cases; of these, 2.5% had a PL bundle tear. From our own clinical experience, the frequency of symptomatic partial ACL tears is in the range of 5% to 10%.

Patients with a symptomatic AM or PL bundle tear usually complain of unspecific symptoms like recurrent pain and swelling. More specifically, patients with a symptomatic AM bundle tear describe an anterior instability during activities of daily living and during sports activity similar to a complete ACL tear. They usually show a significantly increased (1+) anterior drawer test at 90° of knee flexion and a KT-1000 side-to-side difference between 2 and 4 mm. The anterior translation in the Lachman test at 30° is rather small (0 to 1+) and the pivot-shift test is negative or only slightly positive (0 to 1+).

In contrast, patients with a symptomatic PL bundle tear complain of rotational instability with pivoting sports rather than complaining of a significant anterior instability with activities of daily living or sports. Nonpivoting sporting activity might still be performed by the patient without major problems, but pivoting sports (e.g., football or soccer) have to be given up because of recurrent problems with rotational instability. Clinical examination of these patients often shows a positive pivot-shift test (1+), while the anterior drawer test and the Lachman test might be 0 to 1+. The KT-1000 usually shows a small side-to-side difference of 1 to 3 mm.