5 Anterior (and Posterior) Cruciate Ligament Reconstruction

5.1 Technique and Method

The imaging technique and patient positioning in evaluating graft integrity are essentially the same as for assessing the natural anterior and posterior cruciate ligaments. Supplementary thin-slice images in parasagittal or paracoronal orientations along the requisite course of the ligament should be acquired as needed.

5.2 Anatomy

Reconstruction of the cruciate ligaments is usually performed using tissue from other sites of the body as autografts. Because of numerous disadvantages, allografts and prosthetic ligaments have mostly been abandoned.

The most common graft sources in autograft reconstruction of the ACL are the patellar tendon and the hamstring tendons (semitendinosus and gracilis). In more recent approaches using the hamstring tendons, the graft is run in up to four parallel strands in order to match or even surpass the strength of the natural ligament.

The main factors determining the permanent stability of cruciate ligament substitutes are the selection of proper attachment sites that take into account the anatomic ligament attachment sites (as described in Chaps. 3 and 4 on cruciate ligaments), the anchoring of the graft near the attachment site, and the prevention of hollow space formation along the length of fixation.

Regarding graft fixation, a basic distinction is made between fixation near the insertion site and fixation distant from it. Near fixation is mainly done using foreign materials such as inference screws made of titanium or bioabsorbable polymers. It can also be done without introduction of such materials using the press-fit technique. Distant fixation is secured by anchoring screws, staples, or round/oval metal buttons.

Distant fixation has the disadvantage of requiring fixation along an extended stretch of the graft, which reduces its stiffness. There is an increasing tendency to attempt to refill hollow spaces in the bone tunnel with spongiosa, most of which is collected during drilling.

Ligament grafts are rotated on their longitudinal axis in such a way that the fibers run nearly parallel in extension and twist around each other to various extents with flexion. Deliberately overrotated grafts have not proven effective.

Ligament reconstruction is frequently combined with enlargement of the intercondylar space, in particular of the anterior roof portion, by a so-called notch plasty to ensure undiverted sliding of the graft, especially in near extension.

5.3 Normal MRI Appearance

The MRI appearance of a successfully reconstructed ACL varies with the surgical technique employed and the material used (autograft or allograft). Patellar tendon grafts are the internationally preferred material for ligament reconstruction because they are superior to prosthetic materials.

The patellar tendon graft is fixed in a tibial and femoral bone tunnel. Metallic implants or metal debris in this area often produce artifacts on MR images. In a normal graft, the bone tunnel walls are smooth and decrease in signal intensity over time. The marrow space outside the bone tunnel area shows no changes.

Postoperatively the ligament graft has absent or very low signal intensity on T1- and T2-weighted images. The formation of granulation tissue and increasing vascularization produce increasing signal intensity 6–8 months after surgery, which may mimic contour thinning. Thereafter, the graft typi-
cally returns to its earlier thickness and the signal intensity decreases again (Figs. 4.1–4.5).

5.4 Pathomechanism

The selection of inadequate fixation sites, long-stretched and loose fixation, large hollow spaces, and weakness of the graft material may result in secondary failure of the reconstructed cruciate ligament.

“Genuine” graft failure, however, is caused by spontaneous lengthening of the grafted tissue. Recurrent damage requires careful analysis in terms of severity in order to differentiate true repeat rupture caused by trauma from instabilities due to gradual graft failure.

Besides graft failure, scar formation limiting the range of motion is a frequent cause of postoperative complaints. Excessive fibrous tissue formation (arthrofibrosis) may be localized (local causes) or generalized (primarily autoimmune causes).

A known cause of extension loss of the knee after ACL reconstruction that results from a true mechanical block is localized anterior fibrosis. This so-called cyclops lesion is a polyp-like structure consisting of fibrous granulation tissue about 1 cm in thickness that extends anterior to and along the graft between the graft and the intercondylar wall.

5.5 Pathophysiology

The most common mistake made in ACL reconstruction is incorrect femoral fixation in the anterior portion of the lateral intercondylar wall instead of the posterior portion, typically resulting in limited knee flexion due to the increasing tension that develops with flexion.

5.6 MRI Signs of Abnormal Findings

- Assessment of the bone tunnel (femoral insertion should ideally be as posterior as possible and somewhat higher than that of the natural ligament, tibial insertion at least 2 cm anterior to the anterior margin of the PCL attachment but not in front of the projection of Blumensaat’s line in knee extension – notch impingement).

- Margins of bone tunnel (blurring, lytic zones with widening of tunnel exit and entrance in about 25% of patients operated on).
- Signal intensity of tunnel (reduced signal on T1-weighting and increased signal on relative T2-weighting for up to 1 year – edema phase; increasing hypointensity of the tunnel thereafter).
- Increased signal intensity in the course of the ligament graft (focal or generalized; Fig. 5.7).
- Irregular internal structures (spreading of fibers, blurring, partial discontinuity).
- Changes in diameter (focal or generalized thickening/thinning; Fig. 5.6).
- Changes in contour (irregular, partial/complete disruption; Figs. 5.8 and 5.9).
- Changes in course (curving, kinking, abnormal orientation, retraction).
- Paraligamentous changes: hemorrhage, pseudomass, osteophytic processes at the roof of the intercondylar fossa or at the tibia with graft impingement.
- Rupture of graft with residual tibial ligament portion bending anteriorly toward Hoffa’s fat pad while femoral ligament(892,837),(949,998)
- Formation of fibrous granulation tissue in front of and along the ACL graft (cyclops lesion).
- Femorotibial malalignment.

5.7 MRI Grading

As of yet there is no generally accepted international classification of injuries to reconstructed cruciate ligaments.

The classification proposed by Yamato and Yamagishu (1992) distinguishes 4 categories:

Category 1: Graft not disrupted and of low signal intensity throughout its intra-articular course.
Category 2: Low signal intensity restricted to femoral graft portion.
Category 3: Low signal intensity restricted to tibial graft portion.
Category 4: Nonvisualization of low-signal-intensity structure.