ACL Stability, Function, and Arthritis: What Have We Been Missing?

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The anterior cruciate ligament (ACL) is the primary restraint to anterior tibial displacement and a secondary stabilizer of tibial rotation. Of the 200,000 ACL tears per year in the United States, approximately 50% undergo arthroscopic reconstruction. The goal of management of ACL insufficiency is to restore knee function, primarily to allow patients to return to preinjury activity levels and potentially to prevent the onset and progression of knee osteoarthritis. The ACL is composed of 2 bundles: the anteromedial (AM) bundle and the posterolateral (PL) bundle. Functional tensioning of the 2 bundles depends on the knee’s range of motion. Close to extension, the AM bundle is loose and the PL bundle is tight. When the knee is flexed, the AM bundle is tight and the PL bundle is loose.

Several authors have proposed anatomical reconstruction of the AM and PL bundles (double-bundle reconstruction) as the ideal reconstructive procedure to obtain anteroposterior and rotational stability. The concept of double-bundle ACL reconstruction arises from biomechanical studies demonstrating the inability of some single-bundle techniques (reconstructing only the AM bundle) to fully restore knee stability and longitudinal studies showing the development of osteoarthritis in patients who underwent single-bundle ACL reconstruction.

Restoration of Functional Knee Homeostasis

The knee joint works in an optimal fashion through the precise complex interaction of the nervous and musculoskeletal systems. Proprioceptive afferent neural input is the basis of neuromuscular coordination that influences the biomechanical behavior of the knee, including the ACL.

Some structures contribute to the anteroposterior and rotational stability provided by the ACL as secondary restraints. The structures of the posterolateral corner of the knee assist the ACL to prevent anterior tibial translation and anterolateral tibial rotation relative to the femur. The medial collateral ligament, the posteromedial aspect of the capsule, and the hamstring and quadriceps muscle complexes all restrain anterior tibial translation. Postural instability is found in patients with ACL-deficient knees, who report a giving way of the knee, but is not found in patients with ACL-deficient knees, who are able to function without their knee giving way. At times, these secondary structures could produce valid compensation in ACL-deficient knees, justifying in part why some patients exhibit normal or near normal function despite an ACL tear. Other times, these structures are also compromised or the compensatory mechanisms are inadequate to replace the function of the ACL, and these patients develop functional instability. In essence, restoration of stability of ACL-deficient knees depends not only on surgical results but also on anatomical, biomechanical, and functional (neuromuscular) factors.

Return to Preinjury Activity Level

Patients who report no repeated giving way of their knee may be able to return to their preinjury activity level without surgery. Noyes et al described the relationship between the extent of radiographically evident osteoarthritis changes in the knee and giving way in functionally instable patients. This may justify

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that ACL deficiency associated with knee joint instability warrants surgical reconstruction.

Favorable outcomes following single-bundle ACL reconstruction range from 69% to 90%,9,10 with some inconsistency between clinical results on anteroposterior (Lachman test) and rotational (pivot shift test) stability. These variable outcomes have been cited as a consequence of the inability of single-bundle reconstructions to adequately restore rotational stability.11-13

Double-bundle reconstruction techniques have been reported to provide superior rotational stability than the single-bundle technique.3,6 However, a single-bundle ACL reconstruction where the femoral tunnel is placed more horizontally (toward the 9-o’clock position) could be similarly effective in restoring stability against rotational loads. Return to preinjury activity level is not only dependent on the function of knee stability, but also on other variables, including whether patients perceive their knee to be stable, patient motivation, or an associated lesion that could influence clinical outcomes (eg, chondral lesions, meniscal tears, or other ligament injuries). Furthermore, time from injury to surgery and rehabilitation can influence outcome.

Although rehabilitation specialists have tried to devise rehabilitation programs to maximize muscular function following ACL reconstruction, patients with functionally unstable knees show an increased trend in quadriceps strength deficits 6 months after ACL reconstruction, a time when many surgeons would consider athletes ready to return to sport activity.14,15

Currently, a lack of Level I evidence exists on rehabilitation programs specifically tailored to double-bundle techniques. The description of the rehabilitation regimens prescribed postoperatively are not detailed enough to allow conclusions. The original work on accelerated rehabilitation proposed was specific for patellar–tendon bone graft reconstruction.16,17 Hamstring single-bundle rehabilitation programs recommend a slower progression within the first 2 months with a similar deadline for return to sport. To the current authors’ knowledge, programs specifically for double-bundle reconstruction have not been developed or tested in randomized trials. In future randomized, controlled trials, details about postoperative rehabilitation must be given to improve the methodological quality of the studies and to all surgeons to evaluate the efficacy of correct rehabilitation.

**Prevention of Osteoarthritis**

One of the rationales for performing ACL reconstruction is prevention of osteoarthritis progression. However, this contention is debatable. Major risks for osteoarthritis are meniscal resection and chondral damage, but even well-conducted longitudinal studies report a wide variety of patients in terms of age and sports activity.

Recently, the thought that an increased risk of osteoarthritis in knees where a single-bundle ACL reconstruction has been performed has arisen from the fact that single-bundle ACL reconstruction does not restore rotation stability. However, modern techniques, with more horizontal placement of the femoral tunnel, allow comparable restoration of rotational stability. Moreover, long-term follow-up of single-bundle quadruple-hamstring ACL reconstruction with appropriately placed femoral tunnels demonstrated that this is not necessarily the case.18 Double-bundle techniques may address the issue of discrepancy between anteroposterior and rotational stability, but no long-term follow-up reports can be evaluated. It is not known whether single- or double-bundle ACL reconstruction techniques can prevent knee osteoarthritis. It is unclear whether the better rotational stability of the reconstructed knee can reproduce the biological and mechanical behavior of the normal knee with the native ACL.

At this time, it is difficult to understand whether the onset and progression of osteoarthritis is a direct consequence of the ACL reconstruction or is intrinsic in the original injury. The rate of osteoarthritis changes is higher in patients with reconstructed ACLs compared with patients with chronic ACL deficiency who had not undergone ACL reconstruction. Meuffels et al19 compared 25 patients with ACL deficiency who received only conservative management for 10 years with a matched group of patients who received bone–patella tendon–bone ACL reconstruction 10 years previously and found more radiographic evidence of osteoarthrits changes in the surgical group (28% vs 48%, respectively), although the operated knees were more stable.

The successful management of ACL-deficient knee is multifactorial, and the success rate depends on careful holistic management of the condition. This includes (1) assessment of the compensatory capacity of the knee, (2) careful identification and management of associated lesions, (3) the choice of the most appropriate graft and technique (single-bundle in the anatomic position or double-bundle) according to the patient’s pattern of injury and instability and surgeon’s experience, and (4) appropriate rehabilitation programs tailored to the procedure and the patients.

**References**


