Observations on Bone Tunnel Enlargement After Double-Bundle Anterior Cruciate Ligament Reconstruction

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Purpose: The purpose of this study was to determine the amount of tibial and femoral bone tunnel enlargement after double-bundle anterior cruciate ligament (ACL) reconstruction. **Methods:** Twenty-five consecutive patients undergoing primary double-bundle hamstring ACL reconstruction were included in a prospective case series. Femoral fixation was performed by means of 2 EndoButton CL devices (Smith & Nephew Endoscopy, Andover, MA), and tibial fixation was done with 2 bioresorbable interference screws. Magnetic resonance imaging (MRI) was performed in all patients at a mean of 12.3 months postoperatively. Tunnel enlargement was determined by digitally measuring the widths perpendicular to the long axis of the anteromedial (AM) and posterolateral (PL) tunnels on an oblique coronal and axial plane. The MRI measurements were compared with the intraoperative drill diameter. **Results:** The mean tibial AM bone tunnel diameter increased from 0.74 to 1.06 cm, and the mean PL diameter increased from 0.60 to 0.89 cm. The mean femoral AM bone tunnel diameter increased from 0.71 to 0.97 cm, and the mean PL diameter increased from 0.58 to 0.85 cm. Bone tunnel enlargement was 43% ($P = .001$) for both tibial tunnels and 35% ($P = .001$) versus 48% ($P < .001$) for the femoral AM bone tunnel versus the PL femoral bone tunnel. On the tibial side, communication of the bone tunnels occurred in 41% of patients. **Conclusions:** This study shows significant tibial and femoral bone tunnel enlargement on MRI after 4-tunnel double-bundle ACL reconstruction 1 year postoperatively. In 41% of patients separate tibial bone tunnel measurements were impossible because of tunnel communication caused by intraoperative bone tunnel drilling, screw contact, or postoperative bone tunnel enlargement. On the femoral side, no bone tunnel communication occurred. The short-term clinical results were good and were not influenced by tunnel communication. **Level of Evidence:** Level IV, therapeutic case series. **Key Words:** Anterior cruciate ligament reconstruction—Double bundle—Anteromedial bundle—Posterolateral bundle—Hamstrings—Tunnel widening—Magnetic resonance imaging.

The phenomenon of bone tunnel enlargement after single-bundle anterior cruciate ligament (ACL) reconstruction was reported previously and is a common postoperative finding for hamstring autografts, patellar tendon autografts, and allografts.[1-14] The cause is unclear, but most authors favor a multifactorial biologic and biomechanical process.[1,6,13,15,16]

Levels of osteolytic cytokines (interleukin 1β, interleukin 6, bone morphogenetic protein, tumor necrosis factor α, nitric oxide) affecting bone resorption are increased after ACL reconstruction and seem to play an important role in tunnel enlargement.[4,6,8,17-21] Micromotion of the tendon graft in the bone tunnel ("bungee cord" effect, "windshield wiper" effect)[6,16] and "redirecting forces at the tunnel entrance,"[22] as well as graft fixation in relation to the joint line,[23,24] might be even more important.

Recently, ACL reconstruction has focused on the double-bundle technique, reconstructing the anteromedial (AM) and posterolateral (PL) bundle separately while creating 2 femoral and 2 tibial bone

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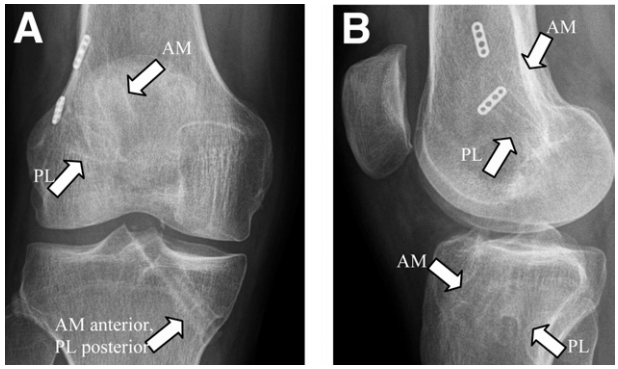

Figure 1. Standardized radiographs with (A) anteroposterior view and (B) lateral view of a double-bundle ACL reconstruction with hamstrings, with two 20-mm EndoButton CL devices for femoral fixation and two bioresorbable 30-mm Milagro interference screws for tibial fixation.

tunnels close to each other at the ACL footprint.[25-30] In this situation intraoperative bone tunnel communication caused by drilling as well as postoperative bone tunnel enlargement could lead to a large common AM-PL bone tunnel at the joint level. This bony defect might become a serious problem for primary stability of the ACL reconstruction and for graft fixation in case of revision surgery. On the other hand, tunnel enlargement might be reduced by creating a more anatomic ACL reconstruction.

The purpose of this prospective case series was to determine the amount of tibial and femoral bone tunnel enlargement after double-bundle ACL reconstruction. Magnetic resonance imaging (MRI) was performed to monitor the amount of bone tunnel enlargement at 1 year postoperatively. The hypothesis of this study was that tunnel enlargement might be reduced by a more anatomic ACL reconstruction with potential biomechanical advantages and better tendon-to-bone contact in 4 separate smaller bone tunnels. To our knowledge, this is the first study to describe this particular issue.

Table 1. *Demographic Data (N = 22)*

	Data
Age (yr) [mean (range)]	28 (15-42)
Female/male	2/20
Right side/left side	13/9

METHODS

In a prospective case series 25 patients with ACL rupture of the knee underwent a primary ACL reconstruction with 4-strand semitendinosus and gracilis tendon autograft via a double-bundle technique reconstructing the AM and PL bundle (Figs 1 and 2a).

Inclusion criteria were a unilateral ACL rupture, no previous knee ligament surgery, no additional knee ligament injuries, no Outerbridge grade 3 or grade 4 arthritic changes, no malalignment, and a normal contralateral knee.

A total of 77 patients underwent ACL reconstruction in the time period between May and August 2004 by the same surgeon. In all patients a preoperative assessment including history, clinical examination, objective knee laxity as determined by use of the KT1000 Arthrometer (MEDmetric, San Diego, CA),[31] Cincinnati knee score, objective and subjective measures based on the International Knee Documentation Committee (IKDC) 2000 knee form, and radiographs was performed. The 25 patients who were included in the study were selected on a randomized basis in the operation theater. The demographic parameters of these patients are outlined in Table 1. All other pa-

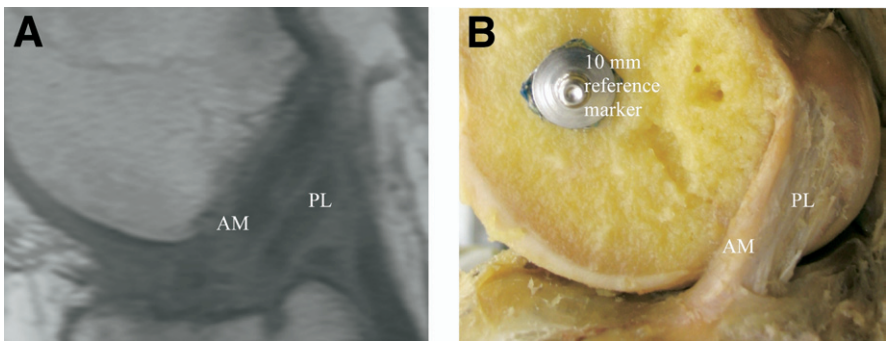

Figure 2. (A) Sagittal MRI scan of double-bundle ACL reconstruction with AM and PL bundle in full extension. (B) Sagittal view of cadaveric knee with intact AM and PL bundle of ACL in extension for comparison.