Electronic Appendix

The posterior cruciate ligament was cut, and the remaining tissue fibers were dissected away from the bone cap. An outline of the ligament's femoral footprint was marked on the bone surface (Fig. E-1). With use of alginate casting material, two cast acrylic replicas of the bone cap were fabricated for attachment to the load cell. Each replica had 7.5-mm tunnels placed at two locations within the footprint. In the first replica, the anterolateral and posteromedial tunnel edges were located at the anterolateral and posteromedial margins of the footprint, respectively (Fig. E-1). This left a wide bridge of acrylic between the tunnels that averaged 5.5 ± 0.4 mm (range, 4.0 to 7.5 mm). In the second replica, the anterolateral tunnel was placed as it was in the first, but the posteromedial tunnel was drilled in order to leave a narrow bridge that averaged 2.9 ± 0.4 mm (range, 2.5 to 4.0 mm). This was the minimum thickness of acrylic possible to maintain the structural integrity of the acrylic cap.

The acrylic cap replica was fixed to the end of a hollow stainless-steel cylinder connected to the tip of the load cell (Fig. E-2). A 21-mm-wide tibial bone block from a bone-patellar tendon-bone allograft was fashioned into a tibial inlay graft. The patellar tendon was split into a Y configuration with two separate bone blocks; the anterolateral and posteromedial grafts were 11 and 8 mm in width, respectively. Each cap replica was split with a parting line at the tunnels. A small screw passing through the acrylic bridge was used to secure the two halves of the cap together. When reassembled, each graft bundle could be shaped into a circular cross section and placed into a 7.5-mm tunnel, while sliding freely within it. This was accomplished by placing the bone plug on the other side of the cap replica. Thus, 11 and 8-mm bone plugs could be used with the tendon portions able to pass freely through 7.5-mm tunnels.

Each bone block at the patellar end of the graft was attached to a thin stainless-steel cable with use of an interlocking thin-plate sandwich-type construct (Fig. E-2). The bone-block cables passed through the load cell and through a split clamp that was used to fix the grafts. Each graft could be tensioned and fixed independently.

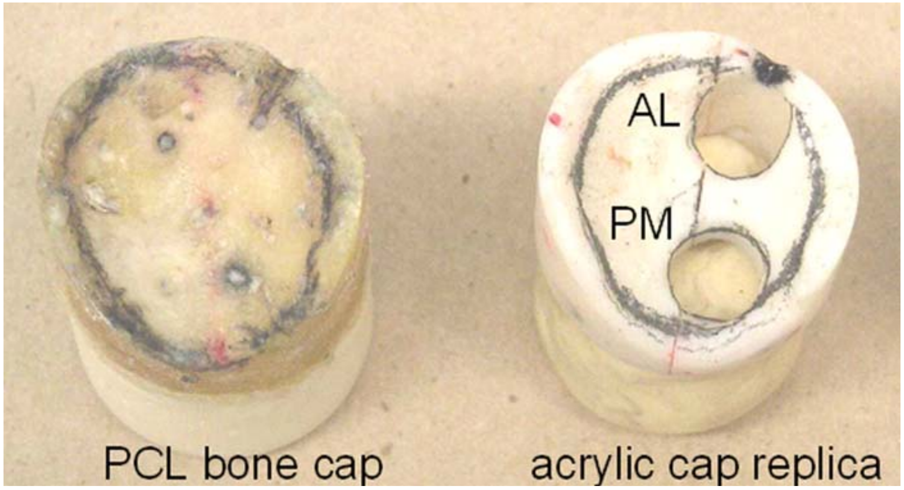

Fig. E-1

A native posterior cruciate ligament bone cap is shown at left; the ligament fibers have been removed from the cortical bone surface, and an outline of the femoral footprint has been drawn on the bone surface. A cast acrylic replica of the native bone cap (with the accompanying footprint) is shown at right. Anterolateral (AL) and posteromedial (PM) tunnels are shown for a wide-bridge tunnel configuration. The parting line for separating the two halves of the cap replica is visible near the tunnels.

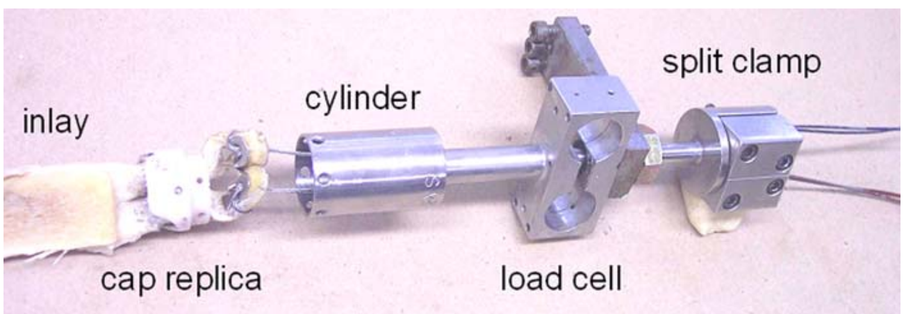

Fig. E-2

View of the graft-load cell assembly. The inlay grafts pass through tunnels in the acrylic cap replica. The cap replica is fixed with screws to the end of the hollow metal cylinder mounted at the tip of the load cell. Thin stainless-steel cables, attached to the graft bone blocks, pass through the interior of the metal cylinder and through the load cell to a split clamp. The cables are used to tension and fix the graft bundles independently.

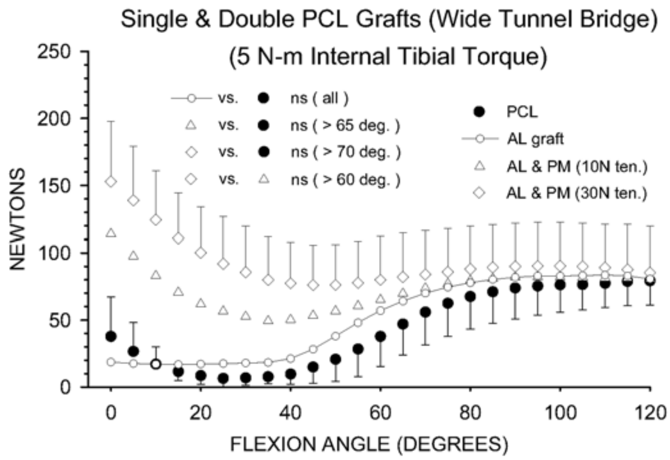

Fig. E-3

Mean curves of resultant force versus knee-flexion angle with 5 N-m of applied internal tibial torque shown for the intact posterior cruciate ligament (PCL), a single-bundle graft placed in the anterolateral (AL) tunnel, a double-bundle graft with the posteromedial (PM) graft under 10 N of tension (ten) and in the wide-bridge tunnel, and a double-bundle graft with the posteromedial graft under 30 N of tension and in the wide-bridge tunnel. Standard deviations are indicated by error bars. All comparisons revealed a significant difference ($p < 0.05$) unless indicated by ns (not significant).

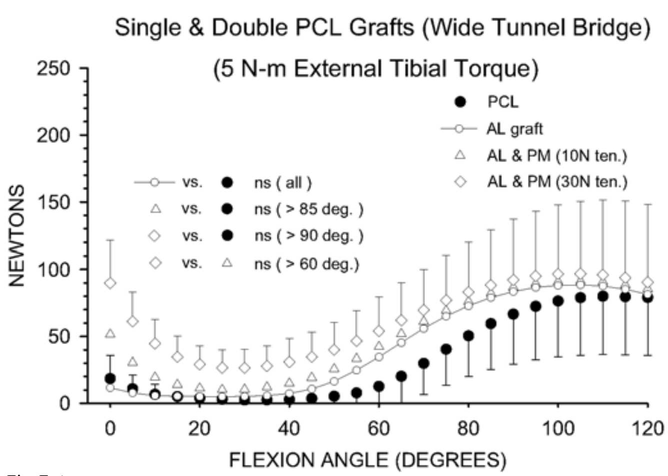

Fig. E-4

Mean curves of resultant force versus knee-flexion angle with 5 N-m of applied external tibial torque shown for the intact posterior cruciate ligament (PCL), a single-bundle graft placed in the anterolateral (AL) tunnel, a double-bundle graft with the posteromedial (PM) graft under 10 N of tension (ten) and in the wide-bridge tunnel, and a double-bundle graft with the posteromedial graft under 30 N of tension and in the wide-bridge tunnel. Standard deviations are indicated by error bars. All comparisons revealed a significant difference ($p < 0.05$) unless indicated by ns (not significant).

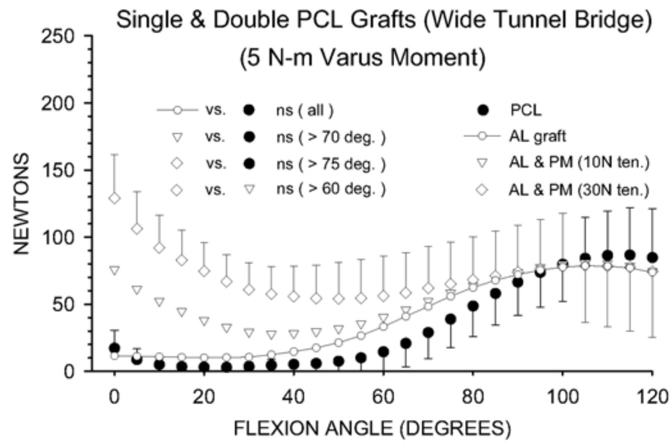

Fig. E-5

Mean curves of resultant force versus knee-flexion angle with 5 N-m of applied varus moment shown for the intact posterior cruciate ligament (PCL), a single-bundle graft placed in the anterolateral (AL) tunnel, a double-bundle graft with the posteromedial (PM) graft under 10 N of tension (ten) and in the wide-bridge tunnel, and a double-bundle graft with the posteromedial graft under 30 N of tension and in the wide-bridge tunnel. Standard deviations are indicated by error bars. All comparisons revealed a significant difference ($p < 0.05$) unless indicated by ns (not significant).

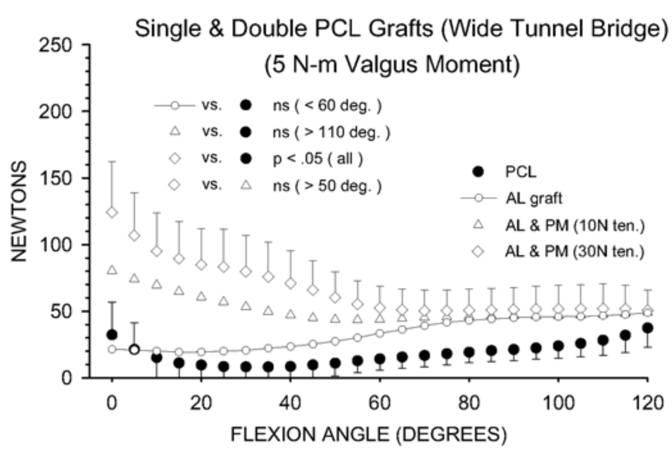

Fig. E-6

Mean curves of resultant force versus knee-flexion angle with 5 N-m of applied valgus moment shown for the intact posterior cruciate ligament (PCL), a single-bundle graft placed in the anterolateral (AL) tunnel, a double-bundle graft with the posteromedial (PM) graft under 10 N of tension (ten) and in the wide-bridge tunnel, and a double-bundle graft with the posteromedial graft under 30 N of tension and in the wide-bridge tunnel. Standard deviations are indicated by error bars. All comparisons revealed a significant difference ($p < 0.05$) unless indicated by ns (not significant).

TABLE E-I Mean Anterior-Posterior Knee Laxities with ±200 N of Applied Tibial Force and Use of Narrow-Bridge Acrylic Cap

	Anteroposterior Laxity* *(mm)*					
	At 0° Flex.	At 10° Flex.	At 30° Flex.	At 45° Flex.	At 70° Flex.	At 90° Flex.
Intact knee	9.2 ± 1.2	13.0 ± 1.9	14.6 ± 2.4	14.2 ± 2.0	13.2 ± 1.9	13.0 ± 2.1
Single anterolat. graft at laxity-match tension	11.1† ± 1.1	14.2† ± 1.7	15.6† ± 2.2	14.9 ± 2.2	13.3 ± 1.5	12.7 ± 1.9
Anterolat. graft and posteromed. graft at 10-N tension	10.1† ± 1.0	12.8 ± 1.9	14.8 ± 1.9	14.7 ± 2.2	13.0 ± 1.5	12.4 ± 1.8
Anterolat. graft and posteromed. graft at 30-N tension	9.4 ± 1.1	11.7† ± 1.3	13.7 ± 1.6	13.9 ± 1.7	12.9 ± 1.5	12.5 ± 2.1

*The values are given as the mean and standard deviation. †The mean value was significantly different from the value in the intact knee ($p < 0.05$).

TABLE E-II Mean Changes in Laxity After Adding Posteromedial Graft Tensioned to 10 or 30 N and Use of Narrow-Bridge Acrylic Cap*

	At 0° Flex.	At 10° Flex.	At 30° Flex.	At 45° Flex.	At 70° Flex.	At 90° Flex.
Laxity with anterolat. graft alone *(mm)*	11.1 ± 1.1	14.2 ± 1.7	15.6 ± 2.2	14.9 ± 2.2	13.3 ± 1.5	12.7 ± 1.9
Laxity change after adding posteromed. graft tensioned to 10 N	−1.0† ± 0.7	−1.4† ± 1.3	−0.8† ± 1.5	−0.2 ± 0.7	−0.3 ± 1.2	−0.3 ± 1.2
Laxity change after adding posteromed. graft tensioned to 30 N	−1.7†‡ ± 0.8	−2.5†‡ ± 1.9	−1.9†‡ ± 1.8	−1.0†‡ ± 1.3	−0.4 ± 1	−0.2 ± 1.2

*The values are given as the mean with the range in parentheses. †A significant change from the value for the anterolateral graft alone ($p < 0.05$). ‡A significant change from the value for the posteromedial graft tensioned to 10 N ($p < 0.05$).