Patellar Tendon Versus Quadrupled Bone–Semitendinosus Anterior Cruciate Ligament Reconstruction: A Prospective Clinical Investigation in Athletes

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Purpose: Patellar tendon and hamstrings are both used in anterior cruciate ligament (ACL) reconstruction, and comparisons have been reported with different results. The purpose of this clinical study was to compare the results of ACL reconstruction in athletes with 2 different graft types, both using bone-to-bone healing: bone–patellar tendon–bone graft and a quadrupled bone–semitendinosus graft. **Type of Study:** Outcomes study. **Methods:** From 1994 to 1997, 2 groups of 40 athletes who underwent ACL replacement with patellar tendon and quadrupled bone–semitendinosus grafts were prospectively evaluated. Preinjury activity level, age, and gender were comparable in both groups. All patients were operated on by the same surgeon within 5 months from injury and underwent group-specific rehabilitation programs. An independent examiner performed the final evaluations at 36 months. Review included clinical examination, radiographs, computed analysis, isokinetic and functional strength tests, and subjective and objective evaluation with standard knee scores. Additional procedures were recorded. Statistical analysis was performed with both parametric and nonparametric tests. **Results:** Average surgical time was longer with the semitendinosus graft, and postoperative pain was higher in the patellar tendon group. Standard knee evaluation scores and subjective assessment revealed no significant differences. Isokinetic testing of flexion-extension and internal-external rotation showed lower quadriceps strength and a mild deficit of external rotation in the patellar tendon group and slightly lower flexor strength in the semitendinosus group at 12 months. Computerized laxity analysis showed no difference between the 2 groups with 90% of patients having less than 3 mm side-to-side difference, with a gender difference in the semitendinosus group. Kneeling pain was higher in patellar tendon group. **Conclusions:** The bone–patellar tendon–bone and quadrupled bone–semitendinosus autograft provide excellent grafts for ACL reconstruction. Both techniques are comparable regarding final stability, but in patients with extensor mechanism problems or those who engage in sports with a high incidence of patellar tendonitis, the semitendinosus graft should be considered. **Key Words:** ACL reconstruction—Patellar tendon—Semitendinosus—Hamstrings—Graft bone interface.

The surgical treatment of the anterior cruciate ligament (ACL) deficient knee continues to stir debate among many orthopaedic surgeons. Included in the controversy is the selection of graft material to be used for the ACL reconstruction. The bone–patellar tendon–bone and the hamstring tendons are used most frequently. Advantages and disadvantages of each type of graft have been described.[1-8] The advantages of using the bone–patellar tendon–bone graft include strength, ready availability, strong bone-to-bone fixation, and prompt healing of the bone plugs; however, harvesting the central third of the patellar tendon may contribute to dysfunction in some patients.[1-5] Advantages of the doubled semitendinosus and gracilis include adequate strength, avoidance of extensor mechanism complications, possibly less morbidity and decreased postoperative pain.[6-10]

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A review of current literature discussing clinical outcomes after ACL replacement reveals no significant differences between these 2 techniques.[1-5] However, although there seem to be no significant differences between the 2 grafts in clinical outcome, many studies show lower donor site morbidity and a slightly increased anterior laxity with hamstring reconstruction.[6-10] The use of 2 different types of grafts for ACL reconstruction are discussed in this paper; the press-fit patellar tendon graft and the quadrupled bone–semitendinosus graft.

The conical press fit fixation technique is a simple method that offers several advantages, including biologic graft healing and the absence of any intra-articular hardware, making revision surgery easier. The use of quadrupled semitendinosus graft was suggested by Rosenberg and Cooley[8] and Rosenberg and Pazik[11] to compensate for the mechanical inferiority of a doubled tendon and avoid harvesting the gracilis. The hypothesis of this prospective study among athletes was that the quadrupled bone–semitendinosus graft could provide the same stability as a bone–patellar tendon–bone graft with a decreased morbidity.

METHODS

From 1994 to 1997, we performed 150 ACL reconstructions in 2 hospitals. Patients who satisfied the following criteria were included in the study: (1) athletes playing in competitive sports at regional or national levels or participating in active sports at least 3 times per week, (2) patients with ACL injury, reported within 5 months of injury, including those with associated meniscus tears, and (3) patients whose opposite knee was normal. Patients also had to be willing to follow the same rehabilitation program at the same rehabilitation center. Patients also needed to consent to participation in the study and to be available for follow-up at 3, 6, and 12 months and 3 years after surgery or when requested to attend follow-up.

The following exclusion criteria were used to select patients: (1) subjects with history of injury or ailment in either knee before the index injury; (2) patients with associated ligament injuries, (3) patients with grade III or IV chondral damage or abnormal radiographs, and (4) patients who showed abnormal bone structure on standard knee radiographs.

The first 40 patients in each institution who met these criteria were included in the study. The 40 patients who underwent ACL reconstruction in institution A (a social medicine hospital) received a patellar tendon graft (PT), and the 40 patients in institution B (a private hospital) received a bone–semitendinosus graft (STB). Thus, we had 2 simultaneous groups of consecutive patients. The choice of where to have the surgery performed was the sole decision of the patient, but was mainly influenced by economic considerations because one institution was a private hospital and the other a social medicine institution.

All patients were treated primarily with anti-inflammatory medicines and a rehabilitation program with the goal of regaining full range of motion of the knee. All patients underwent surgery performed by the same surgeon and followed a "group-specific" rehabilitation program at the same rehabilitation center.

The surgeon and a physical therapist examined all subjects independently at 3, 6, and 12 months. An independent examiner performed final evaluations at 36 months for both groups. Standard anteroposterior (AP) and lateral weight-bearing roentgenographic studies performed on the first postoperative day were compared with those at final follow-up to evaluate tunnel widening. This was measured in terms of percentage change in the tunnel area, with a 50% increase seen as tunnel widening, as proposed by Clatworthy et al.[12]

Subjective evaluation was performed with the International Knee Documentation Committee (IKDC) questionnaire, which included present symptoms, range of motion, joint stability, kneeling pain, satisfaction, and return to sport. In the IKDC functional chart, patients were asked to score the treated knee, with the normal knee considered to be 100%. Extension loss was measured with the patient prone and compared with the normal knee. Flexion loss was measured with the patient supine and compared with the uninvolved knee. The patellofemoral joint was examined for crepitus, pain, swelling, and tightness in the retinaculum. Pain over the metal hardware and anterior knee pain were recorded by an independent examiner using a visual analogue scale (VAS) at 1-year and at final evaluation.[13]

Computerized laxity analysis was performed with a knee motion analyzer (OSI CA4000, Orthopedic System, Hayward, CA) preoperatively, at 3 months, at 1 year, and at final evaluation. Anteroposterior tibial translation was measured by applying a 200-N force, and dynamic tests were performed during active flexion-extension against resistance.[14-16]

Isokinetic testing for evaluation of muscle strength was performed with the Biodex multijoint system (Biodex, Shirley, NY) by a single examiner. The tests were performed at 3, 6, and 12 months after surgery. The maximum peak torque in flexion and extension

was measured at speeds of 60°, 180°, and 300° per second. Total work and hamstring/quadriceps ratio were calculated. We also studied the internal and external rotation muscle strength to evaluate whether there is any deficit of muscle strength due to semitendinosus graft harvesting. The maximum peak torque deficit was measured in internal and external rotation, with the patient in a sitting position and the knee flexed at 90°. This was done at speeds of 60°, 180°, and 300° per second.

All patients underwent a series of functional tests. In the hop test, take-off and landing in equilibrium on the same lower extremity and free use of arms are used. Three jump trials were performed for each leg, measuring the average distance and comparing the healthy and pathologic limbs. Tegner and Noyes scales, standard IKDC, Lysholm knee scores, and subjective assessments were also used for final evaluation.

Surgical Technique

The surgeries were performed under general anesthesia in 68 patients and under epidural anesthesia in 12 patients. To reduce total tourniquet time, the tourniquet was used only during graft harvest.

In the PT group, the central one third of the bone–patellar tendon–bone autograft was harvested with a trapezoidal shaped tibial bone block, which was used to obtain a femoral press-fit (Fig 1). The tibial bone plug measured 30 mm in length, 14 mm wide at its base, and 10 mm wide at the bone–tendon junction. The patellar bone plug measured 10 mm wide and 20 to 25 mm long. The total length of the grafts averaged 10 to 11 cm (Fig 2). Using a modified 2-incision technique, a femoral press fit was achieved by inserting the graft in a retrograde fashion through a femoral tunnel. The femoral tunnel was created using a special conical cannulated reamer with a tapering diameter from proximal to distal. The conical bone plug corresponded to the flare of the femoral tunnel so that the plug fit exactly into the femoral tunnel (Fig 3). Tibial fixation was obtained using a metal wire (0.8 mm) tied over a bicortical screw post. The bone block harvest sites were filled with the previously spared cancellous bone, and the incision was closed. A postoperative rehabilitation program as reported by Shelbourne and Nitz[17] was followed.

For the STB group, when hamstring reconstruction was performed, the semitendinosus tendon was dissected and detached proximally but not distally from the tibia. The distal margin of the semitendinosus was detached, along with a bone plug and periosteum to the tibial crest, which was harvested using an osteotome. The required minimum tendon length was 28 cm, which was noted in every case, and the average tendon length was 30 cm. The graft was whipstitched and the tendon was quadrupled, with the bone plug tied at the external surface (Fig 4). The tibial tunnel was positioned at the anatomic ACL insertion with an endoscopic aimer adjusted to a 45° position in the

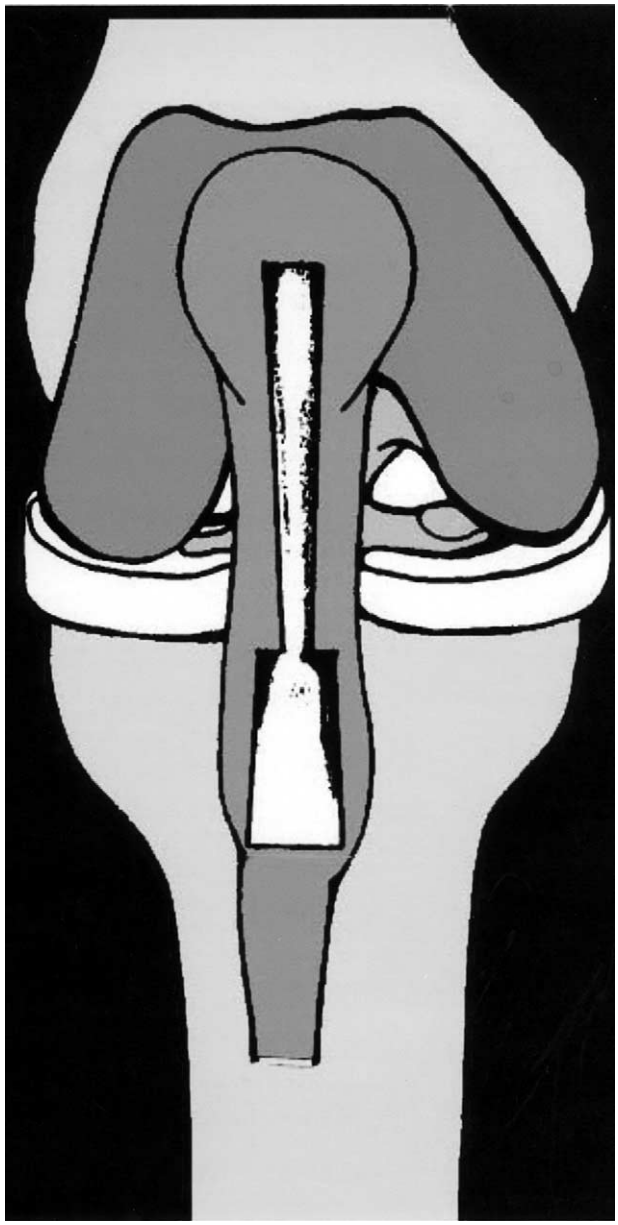

FIGURE 1. The bone–patellar tendon–bone graft harvested with a trapezoidal-shaped tibial bone block.

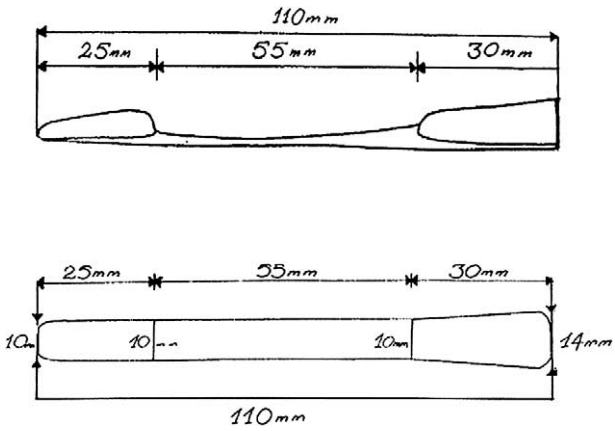

FIGURE 2. The bone–patellar tendon–bone graft and its dimensions.

coronal plane. The alignment was performed at 70° with respect to the medial plateau. The femoral tunnel was positioned about 7 mm in front of the "over the top position" at the 11-o'clock position for a right knee.

Another bone plug harvested during the creation of the tibial tunnel with a coring system was used to fill the tibial tunnel and press-fitted with the graft in the tibial tunnel. Femoral fixation was achieved using one EndoButton (Smith & Nephew Endoscopy, Andover, MA) and tied with a quadrupled 5-mm Mersilene tape; the length of the Mersilene loop was 20 to 30 mm. The graft was pretensioned and preconditioned before tibial fixation with cyclic flexion and extension of the knee under maximum manual traction.

Tibial fixation was obtained with one 8-mm titanium Fastlok device (Neoligaments, Leeds, UK), which was also connected to the graft with a quadrupled polyester tape (Fig 5). The Fastlok is a 2-piece fixation device with staple and buckle that allow triple clamping action on the linkage material. Postoperative rehabilitation followed a program as reported by Rosenberg and Pazik.[11]

Statistical Analysis

For continuous data, we used both parametric and nonparametric tests for the statistic comparison between the 2 groups. For parametric data analysis, the Student *t* test has often been performed in its Welch-modified version, to analyze unpaired samples with different variances. For nonparametric technique, the Wilcoxon rank-sum test has been used (also known as Mann-Whitney statistics). Nonparametric techniques, even if more conservative, allowed us to relax assumptions of normality in sample distributions to obtain a robust confirmation of our results.

For categorical data, we adopted the χ-square test or the Fisher's exact test to evaluate any significant difference between groups. The χ-square test provides better results when used in contingency tables with more than 5 counts per each cell. Fisher's test is better for small counts contingency tables and cannot be used when the sum of counts exceeds 200. We assumed a standard target for significance to be $P < .05$.

The Null hypothesis assumes no difference in means, no differences in ranks, no difference (or contingency) for Student *t* test, Wilcoxon test, and χ-square (or Fisher test), respectively. S-plus statistical software was used to compute the results.

RESULTS

The PT group included 26 men and 14 women, with a mean age of 28 years. The STB group included 22

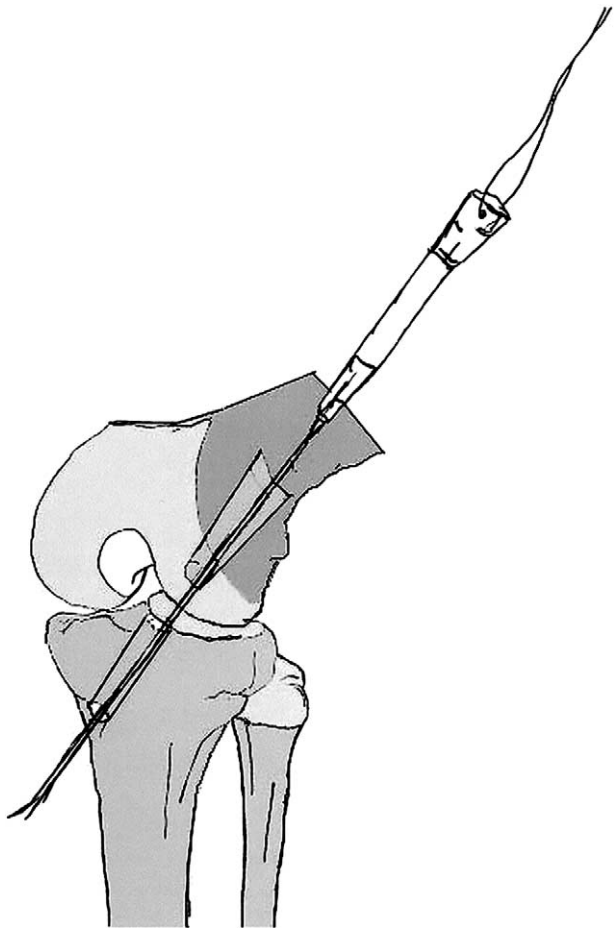

FIGURE 3. Insertion of patellar tendon graft through the conical tunnel in the femur.

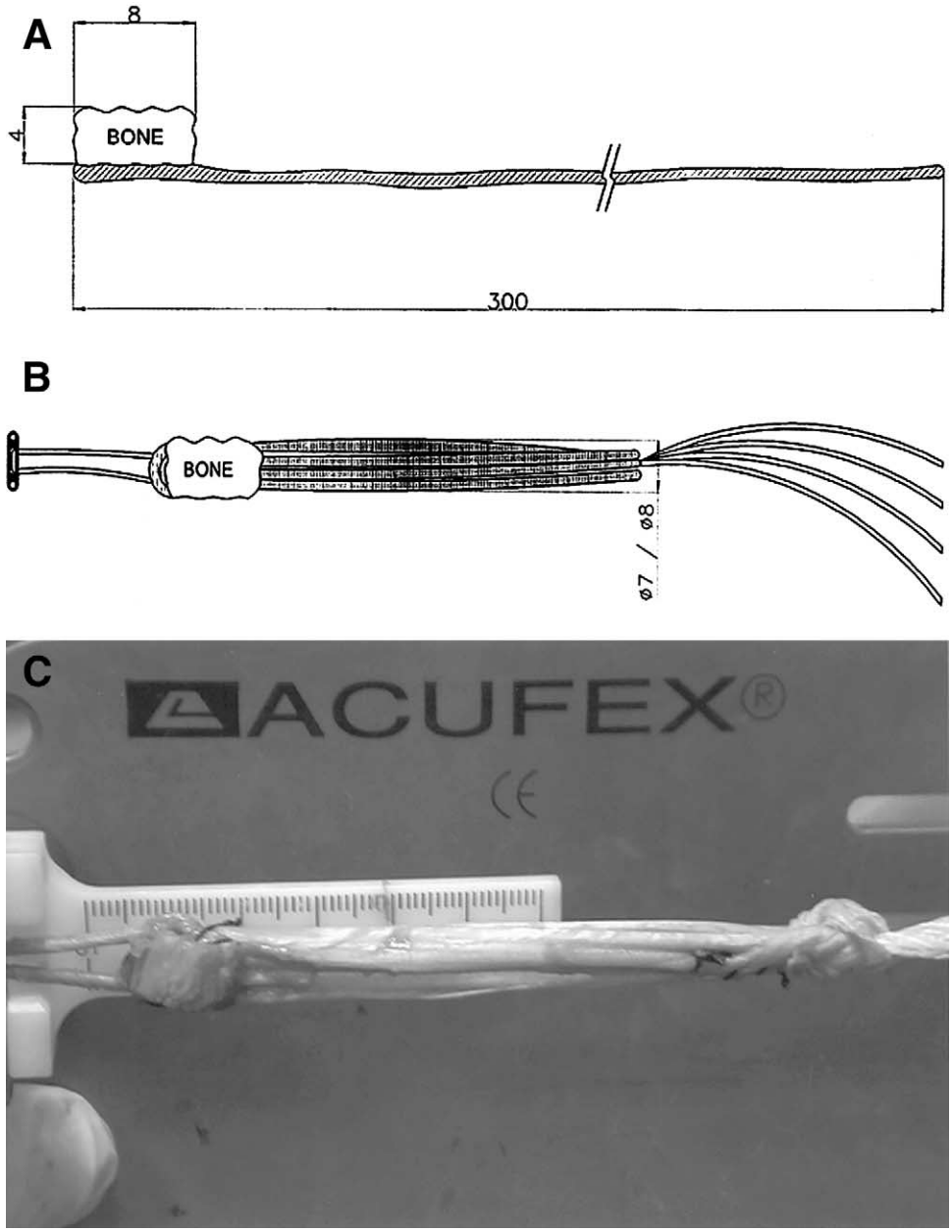

FIGURE 4. The quadrupled bone-semitendinosus graft. (A) The harvested graft with a bone block at its distal end. The average length of the graft is 300 mm; the average size of the bone block is 8 × 8 × 4 mm. (B) The graft is folded on itself. The end with the attached bone block is hooked over the loop of Mersilene so that the bone is on the external surface of the graft. The proximal 2.5 cm is whipstitched with Ethibond No. 1 suture, taking care to attach the bone block securely to the graft surface. At the distal end, 2 strands of 3-mm Poly-tape are secured around the looped ends of the graft using a sliding knot, leaving 4 free strands of tape. (C) Photograph of the prepared graft.

men and 18 women, with a mean age of 29 years. The mean injury-to-surgery interval was 2.5 months (range, 1–5 months), which was similar in the 2 groups. The preinjury activity levels were comparable between the 2 groups (average Tegner Score, 7.5 for both groups).

The 2 groups were comparable in terms of gender, age, and level of sports participation; the type of sports performed by the patients were similar (Table 1). Average surgical time was 83 minutes in the PT group and 90 minutes in the STB group. Harvesting of the grafts required 10 minutes for PT and 16 minutes for STB, and graft preparation took 5 minutes and 15 minutes, respectively. Postoperative pain was higher in the PT group (VAS 7 of 10), and only 20% of the patients were discharged from the hospital within the first 24 hours. For the STB group, 80% of the STB patients (VAS 5 of 10) could return home on oral analgesics.

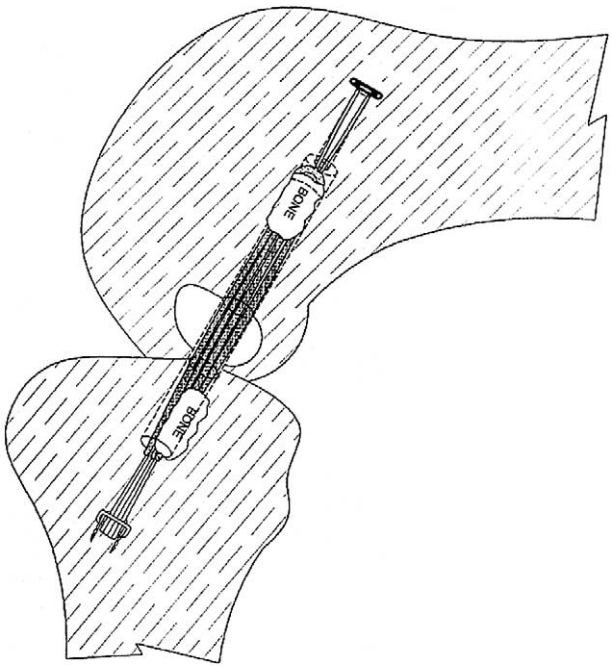

FIGURE 5. The completed reconstruction. The EndoButton with Mersilene tape is secured to the femur. Tibial fixation is achieved by securing the free end of the Poly-tape with a Fastlok. The bone plug removed from the creation of the tibial tunnel has been reinserted to press-fit the graft.

Knee Scores

Final IKDC assessment revealed that 85% of PT patients and 92% of STB had "normal" or "nearly normal" knee joints after surgery. Of the PT patients, 55% were rated group A (normal) versus 60% of the STB patients (Table 2). Using the Fisher exact test, no statistically significant difference between the 2 groups was noted ($P = .8004$).

TABLE 1. *Type of Sports Performed by Patients in the Study Groups*

	PT Group	STB Group
Soccer	6	8
Downhill skiing	8	9
Motocross	6	7
Basketball	6	5
Volleyball	4	4
Tennis	4	3
Mountain bike	3	1
Handball	1	1
Alpinism	1	1
Horse riding	1	1
Total	40	40

TABLE 2. *Knee Assessment Scores*

TEST		PT	STB
Tegner	Preinjury	7.5 (3-9)	7.5 (3-10)
	Postoperative	6.5 (3-9)	6.7 (2-9)
Noyes	Final	88 (60-100)	86 (40-100)
Lysholm	Final	90 (80-100)	92 (80-100)
Hop test (% Deficit)	6 Months	10	9
	12 Months	6	6
Final IKDC	Group A	22	24
	Group B	12	13
	Group C	5	3
	Group D	1	0

Evaluation Form

Tegner activity scale (preoperative and postoperative), Noyes and Lysholm score results did not reveal significant differences between the 2 groups (χ-square test, $P = .9156$; Table 2).

Subjective Assessment

On the IKDC evaluation form, all patients were asked to assess the treated knee, assuming the normal knee as 100%. The PT group had an average score of 80% and the STB group, 85%.

Isokinetic Tests

Isokinetic testing of flexion-extension at 3 months revealed lower quadriceps muscle strength in PT patients (23% extensor total work deficit *v* 7.3% flexor total work deficit) and hamstring strength in STB patients (21.3% extensor total work deficit *v* 22.4% flexor total work deficit) at 60°/s. At the 1-year evaluation, no statistically significant difference was seen at 60°, 180°, and 300° in extension. In flexion, a statistically significant difference ($P = .0164$) was seen in the STB group at 60° and 180°, and no difference was seen at 300°/s. Internal and external rotation revealed a mild deficit of external rotation in the PT group (average, 9%) and internal rotation in the STB group (average, 6%). After 12 months, all patients showed normal internal-external rotation data, with no statistically significant difference as calculated by Welch modified Student *t* test and Wilcoxon method in between the 2 groups.

Computed Analysis

Computed analysis (OSI) was available for all patients at 3-month, 1-year, and 3-year evaluations. This analysis showed that 90% of these patients had less

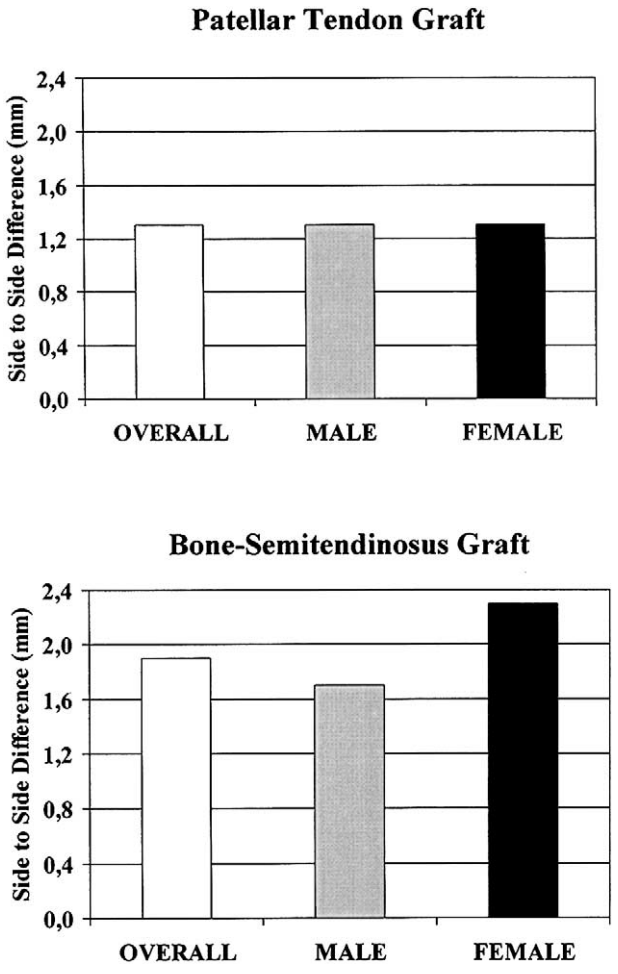

FIGURE 6. Side to side difference in knee laxity between the 2 groups.

than 3 mm side-to-side difference; 8% had between 3 and 5mm; and 2% had more than 5 mm difference. No difference was seen between the 2 groups ($P = .1662$) or between men and women in the PT group. However, we found a small increased laxity in STB females (2.3 mm *v* 1.7 mm) as seen in Fig 6.

Clinical Examination

In the PT group, 15% of the patients reported pain with kneeling (VAS 6 of 10), and 7% of the STB patients reported anterior pain (VAS 4 of 10) on kneeling. Patellofemoral crepitation was found in 20% of PT and 10% of STB patients.

Three patients in the STB group required removal of tibial hardware 1 year after the initial surgery (pain score 8 of 10), but at final follow-up these patients were pain-free. No PT patient required removal of the tibial screw. Greater thigh atrophy was found in the PT group at 3 months, although at 1 year the difference between groups was no longer present.

No differences were found regarding return to sport activities, with 60% of these patients returning to the same preinjury sport and level. Some of the remaining patients changed their level of activity because of a lifestyle change; others decreased activities for fear of a new injury. Roentgenographic evaluation was performed in all patients and revealed no tunnel enlargement or arthritic changes in either group.

Additional Procedures

Four PT patients underwent second-look arthroscopy within the first 8 months because of patellar pain or loss of extension. Surgical findings included an intact ACL graft in all 4 patients: 2 showed cyclops lesions, 1 parapatellar chondropathy (grade III), and 1 failed medial meniscus repair, which required excision. Of these 4 cases, only the patient with parapatellar chondropathy noted persistent pain at final evaluation. Two patients had loss of 8° of extension at the final evaluation. Two female STB patients underwent a second-look arthroscopy at 7 months because of new injuries. The first patient reported a knee sprain during the volleyball game; arthroscopy revealed a partial midsubstance rupture of the graft. Another woman, a semi-professional basketball player, required a partial medial meniscectomy 1 year after surgery, but she had an intact ACL graft. Three patients in the STB group required removal of the 8-mm Fastlok staple from the tibial site because of pain, which settled after the hardware removal.

DISCUSSION

Our study was begun in 1994, when the central one third bone–patellar tendon–bone autograft was unanimously considered the gold standard in ACL reconstruction. However, ACL reconstruction with hamstring autograft was also becoming popular in an effort to reduce the postoperative morbidity associated with patellofemoral pain.[18,19] We analyzed the advantages and disadvantages of patellar tendon and hamstring grafts. The clinical outcomes with these techniques did not reveal overwhelming differences between the two, and many studies show low donor site morbidity but a slightly increased anterior laxity with hamstring grafts.[1,3-5,7,10,20,21] In our series, only 20% of patients in the patellar tendon group were

discharged from the hospital within 24 hours because of pain in the postoperative site.

The most common method of fixation of patellar tendon was with metal interference screws, but these have not gone without complications.[22] To avoid using intra-articular hardware with patellar tendon grafts and to reduce surgical costs in a social medicine hospital setting, we thought of adopting a biological fixation of our grafts. We developed a conical press-fit femoral bone plug fixation technique. The shape of the hole on the femur was made congruent with the bone plug harvested from the tibia so that it could hold and fit snugly.

The use of quadrupled semitendinosus with extra-articular fixation was suggested by researchers[8,11] to compensate for the mechanical inferiority of a doubled tendon and avoid harvesting the gracilis. Furthermore, many authors agreed that harvesting the semitendinosus tendon alone is associated with less morbidity[18,19] and provides strength and a high cross-sectional area.[23-25]

To combine low donor site morbidity with the advantage of bone-to-bone biologic healing, we used a quadrupled bone–semitendinosus construct. Incorporation of the semitendinosus tendon graft in the bone tunnel is the basic requirement for the long-term survival of the cruciate ligament replacement. Therefore, fixation, revascularization, and incorporation of hamstring tendons within the bone are a theoretical as well as practical concern for the surgeon.[26-30]

Weiler et al.[31] and Shino et al.[32] studied the initial fixation strength of the hamstring graft under static and dynamic loading conditions with different techniques. They showed that a hamstring construct with an attached bone plug results in a superior initial fixation strength similar to conventional bone–tendon–bone graft fixation.

We used the bone plug harvested along with the semitendinosus tendon for fixation in the femoral tunnel. To make this ST graft comparable with the bone–patellar tendon–bone construct, we harvested another bone plug during the creation of the tibial tunnel with a coring reamer. This bone plug was press-fit into the tibial tunnel after insertion of the graft.

Recent studies[6,33,34] suggested that the tensile strength of the graft was determined by the quality of soft tissue fixation. Mersilene tape has been indicated as the weaker point in semitendinosus reconstruction with the EndoButton, with a failure load calculated between 492 N and 873 N.[35,36]

Following the suggestion of Ishibashi et al.,[37] we adopted a short polyester tape loop to connect our graft to the button to reduce creep and graft-tunnel motion. We also used cyclic preconditioning of the graft before tibial fixation. Furthermore, the primary stability of a quadrupled hamstring graft was sufficient to allow an immediate accelerated rehabilitation protocol, which involves conditioning and stretching of the graft to sub-failure load.[6,22,38,39,40]

Rehabilitation after ACL reconstruction surgery is prolonged and time demanding. The only difference between our 2 groups was in the first phase of the program. We used the postoperative brace with the knee in full extension in the PT group, and in the STB group, we adopted a brace with extension lock at 10°; this helped us obtain immediate full extension of PT patients while reducing the postoperative hamstring stretch in the STB patients.

Yasuda et al.[10] showed that it is possible to have a complete recovery of isometric hamstring muscle strength after ACL reconstruction by 3 months. In our groups, regaining the muscle strength was slower, but at 1-year follow-up, we found no difference in either group when compared with the opposite side.

Endoscopic hamstring ACL reconstruction has been associated with tibial tunnel enlargement.[12,41-44] The etiology of bone tunnel enlargement is probably multifactorial. Some authors favor biologic components,[2,41] and others favor mechanical factors.[40,42,43] Synovial fluid leakage into the tibial tunnel may also play an influential role, as well as motion of the graft within the tunnel, the so-called “windshield wiper” effect.[40,44,45]

This phenomenon can be related to an incorrect matching of graft-tunnel length with the patellar tendon or the great distance of fixation and graft-tunnel motion when using hamstring tendons. We did not find tunnel enlargement in our series using anatomic fixation and a bone block press-fitted in both the tunnels. Our finding suggests that there may be a biological cause for the high incidence of tunnel widening when using hamstring without filling the tunnel with bone.

One of the features of our study was the evaluation of objective stability after reconstruction of the ACL with a computed analysis system (OSI 4000), believing that it would allow a more objective assessment of the anterior tibial translation than simple KT manual testing. It allowed us to not only test the maximum static load but to perform the dynamic muscle test with flexion and extension exercises as well. An independent examiner other than the surgeon performed the tests to eliminate potential bias. None of these

patients sustained major injuries to the contralateral knee during this interval.

Our study showed that more than 80% of the patients in both groups showed less than 3 mm of side-to-side difference. We did not find major changes between 1- and 3-year test results.

Marder et al.[4] and Harter et al.[46] reported no statistically significant difference when using a patellar tendon or a combined semitendinosus–gracilis tendon with respect to subjective evaluation and objective stability.

Aglietti et al.[47] found no overwhelming difference between the 2 types of grafts. However, a trend toward better objective stability (KT-1000) with the use of the patellar tendon grafts, but there was also more extension loss and patellofemoral problems. Otero and Hutcheson[5] concluded that both the patellar tendon and the semitendinosus–gracilis are good choices in ACL reconstruction, but the patellar tendon autograft provides more stability than the doubled semitendinosus–gracilis tendons. We believe that our results were similar with either graft type because both were constructed with the concept of bone-to-bone healing.

We also noted that with the semitendinosus graft, tibial hardware protrusion above the tibial surface could be a significant cause of pain. Therefore, the protrusion height of the system should be considered when selecting the tibial fixation device of the semitendinosus graft.

Regarding return to sports, we found that only 60% of these patients could return to sports at the preinjury level. This was assessed with standard questionnaires completed by each patient independently. Not all of the patients who returned to preinjury activity levels were classified as IKDC group A: 9 patients (5 STB and 4 PT) were classified as group B. The work of Daniel et al.[48] revealed that restoration of certain laxity parameters alone, like KT1000, after ACL reconstruction does not prove restoration of normal function. A meta-analysis performed by Yunes et al.[49] estimated that 75% of patients undergoing PT ACL reconstruction and 64% of those undergoing hamstring tendon ACL reconstruction returned to preinjury levels of activity. However, direct comparison with our study is difficult, because our study population consisted exclusively of athletes, and the samples included in that meta-analysis were not homogenous and included nonathletes.

CONCLUSIONS

Several conclusions can be drawn from this study. First, bone–patellar tendon–bone and quadrupled bone semitendinosus autografts both provide excellent grafts for ACL reconstruction, with good functional stability of the knee and low primary failure rates. Second, although a high percentage of athletes in the study group had good results in terms of stability, only 60% returned to sports activities at the preinjury level. Normal laxity parameters and commonly used knee scores after ACL reconstruction do not always predict return to preinjury level of function.

Finally, we recommend that patients with pre-existing patellar or extensor apparatus problems, and those performing sports with a high incidence of patellar tendonitis, consider alternative ACL grafts including semitendinosus graft.

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