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Five-Year Results of Single-Incision Arthroscopic Anterior Cruciate Ligament Reconstruction with Patellar Tendon Autograft*

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ABSTRACT

We performed a retrospective study on 80 patients who underwent single-incision arthroscopic anterior cruciate ligament reconstruction with patellar tendon autograft and interference fit screw fixation in 1989. Twelve patients were lost to followup, allowing a clinical assessment of 68 patients to be conducted by independent examiners at 1 and 5 years after surgery, with radiographic assessment at 5 years. Thirty-three patients had chronic anterior cruciate ligament-deficient knees. Three patients reruptured their grafts during sports at 29, 48, and 56 months. At 5 years, 64 patients (98%) had grade 0 or 1 Lachman and pivot shift tests with manual stability testing. Fifty patients (77%) were participating in level I or II activities according to the International Knee Documentation Committee scale. Twenty-nine patients (45%) experienced low levels of pain when performing at their highest activity level. Five (8%) had thigh atrophy greater than 1 cm, and three (5%) had an extension loss of more than 3°. Eleven patients (17%) had tenderness over the graft site when kneeling. Fifteen of 62 patients (24%) had degenerative changes on radiographs, and this was more common in patients with chronic anterior cruciate ligament-deficient knees. Fifty-two patients (80%) had normal or nearly normal knees according to the overall International Knee Documentation Committee score.

Rupture of the ACL often results in functional instability of the knee, with risk of recurrent meniscal injury and early degenerative arthritis.[17,19,22,28,29,34,45] Some patients can manage this functional deficit with intensive rehabilitation and avoidance of activities that commonly cause giving way. Others require the stability afforded by ACL reconstruction to allow them to return to sports and to prevent damage to the menisci.[2,3,10,11,33]

Many techniques have been described to stabilize the ACL-deficient knee.[7–9,13,14,20,23–25,27,30,32,36–38,48,49] In this study, a single-incision arthroscopic technique with bone-patellar tendon-bone autograft and interference screw fixation was used. This has been biomechanically proven to be a stable construct allowing early aggressive rehabilitation.[4,12,14,24,26,31,32] The purpose of this study was to review the 5-year clinical and radiographic results using this technique for ACL reconstruction.

MATERIALS AND METHODS

The study group consisted of 80 consecutive patients with ACL reconstructions performed by the senior author (LAP) between March 1 and November 30, 1989. A single-incision technique with bone-patellar tendon-bone autograft and interference screw fixation was used. During the 5-year study period, 12 patients were lost to followup because they had changed address and occupation and we were unable to contact them further. The remaining 68 patients included 49 men and 19 women. The average age was 27 years (range, 15 to 46). There were 32 right and 36 left knees.

Twenty-four patients underwent reconstruction in the acute phase (less than 3 weeks after injury), and 11 underwent surgery in the subacute phase (3 to 12 weeks after injury). These patients had clinical evidence of ACL instability and, because of their interest in pivoting and

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sidestepping sports, they were thought to be at high risk for functional instability and meniscal injury. There were 33 patients with chronic injuries (greater than 12 weeks since the time of injury), and these patients had failed results after a course of physical therapy aimed at strengthening and sport-specific exercises and were suffering recurrent episodes of giving way.

Patients with associated medial collateral ligament (MCL) injuries were included in the study group. Patients with any other ligament injuries were excluded. Nineteen patients had MCL injuries, and six were treated with a brace to allow MCL healing before ACL reconstruction. Thirteen patients underwent MCL reconstruction at the time of ACL reconstruction.

Operative reports were retrospectively reviewed to document meniscal injuries. Operative notes were documented on a standard form that gave diagrammatic as well as descriptive findings of the arthroscopic examination. Twenty-two patients underwent medial meniscectomy (six of these surgeries had been performed previously), and three had meniscal suturing for unstable red-on-red or red-on-white longitudinal tears. Seventeen patients underwent lateral meniscectomy (three of these surgeries had been performed previously), and six had lateral meniscal suturings. In addition, eight patients had posterior horn lateral meniscal injuries that were stable or healed and therefore not treated. Articular cartilage changes were classified simply as being 1) normal, 2) fraying or fibrillation, or 3) exposed bone. Lesion size was not documented. Osteophyte formation was recorded. Examination of the articular weightbearing surfaces revealed 51 patients with normal chondral surfaces, 9 patients with articular cartilage fraying or fibrillation, and no patient with exposed bone on the articular cartilage surface. There were eight patients with early osteophyte formation (Table 1).

Several patients had previous operative procedures on the affected knee. In addition to the previously reported six partial medial meniscectomies and three partial lateral meniscectomies, there were three diagnostic arthroscopic procedures, two MCL repairs, and one femoral chondroplasty.

The preoperative activity level of each patient was also determined in a retrospective manner based on the International Knee Documentation Committee (IKDC) Evaluation form. The IKDC has divided activity into four levels based on the committee's perception of the risk of injury to the knee. There were 49 patients (72%) participating in level I activities, 17 patients (25%) in level II, 2 patients (3%) in level III, and no patients in level IV activities.

Operative Technique

With the patient under a general anesthetic, a tourniquet was applied high on the thigh and inflated after exsanguination of the leg with an Esmarch bandage. To decrease postoperative pain, a femoral nerve block was performed by the anesthetist using 20 ml of 0.5% bupivacaine with epinephrine. A diagnostic arthroscopic examination was performed using high anterolateral and low anteromedial portals. Preliminary notch clearance and removal of the old ACL stump were performed. Any meniscal lesions were appropriately treated. If meniscal repair was required (unstable longitudinal red-on-red or red-on-white tears), this was performed using an inside-out technique with posteromedial or posterolateral incisions for capsular exposure. A double-barreled suture passer was used to space No. 2 polydioxanone sutures every 5 mm along the length of the longitudinal tear. The sutures were tied over the capsule once the cruciate reconstruction was completed.

Two 2-cm longitudinal incisions were used for graft harvest. The upper incision was located at the distal aspect of the patella, and the lower incision was just medial to the tibial tubercle. A trapezoidal bone block was harvested from the patella, measuring 20 to 25 mm in length and able to pass through a 9-mm gauge. The patellar tendon was incised subcutaneously with a scalpel blade and a 30 × 9 mm tibial bone block was harvested.

The arthroscope was then inserted through a central portal in the infrapatellar incision. This gave a deep view of the notch and allowed appropriate placement of the femoral tunnel. In general, bony notchplasty was not performed except in a few cases where osteophytes had overgrown in the notch. Soft tissue clearance of the notch was completed to visualize the femoral tunnel position 5 mm anterior to the posterior capsule insertion. This was at the 11 o'clock (right) or 1 o'clock position (left) with respect to the apex of the notch.

A power bur was used to initiate the femoral tunnel in its appropriate position, and, with the knee fully flexed, the femoral tunnel was created using a 4.5-mm drill bit inserted from the anteromedial portal and aimed approximately 30° lateral and 30° anterior to the femoral axis. A 2.4-mm Beath pin was inserted in the drill hole followed

TABLE 1
Incidence of Meniscal Surgery and Articular Cartilage Damage

Group	Meniscectomy[a]			Meniscal suture		Arthroscopic findings			
	No. of patients	Med.	Lat.	Med.	Lat.	Normal chondral surface	Chondral injury	Exposed bone	Osteophytes
Acute (N = 24)	8	2	6	0	2	23	1	0	0
Subacute (N = 11)	3	1	2	1	2	10	1	0	0
Chronic (N = 33)	24	19	9	2	2	18	7	0	8

[a] Patients with a meniscectomy before or at the time of ACL reconstruction.

by a 9-mm cannulated drill inserted to the same depth as the length of the patellar bone block.

The tibial tunnel was created using a drill guide inserted through the anteromedial portal. The tip of the guide was placed within the remnants of the ACL stump at a position one-third of the way from the medial end of a line joining the anterior horn of the lateral meniscus and the medial tibial spine. A 4.5-mm drill hole was created first and then a 2.4-mm Beath pin was inserted in the drill hole. The final 9-mm tunnel was formed with a cannulated drill. The length of the tibial tunnel was usually 45 to 50 mm, which just allowed the tibial bone plug to protrude through the tibia. Debris at the aperture of the tibial tunnel was removed to avoid formation of a cyclops lesion.

The patellar tendon autograft was then passed into the knee using nylon pull-through suture, and the bone blocks were positioned in their tunnels and secured. The patellar bone block in the femoral tunnel was placed with the cancellous side facing anteroinferiorly. The knee was fully flexed and an AO 6.5-mm, fully threaded, cancellous screw was inserted via the anteromedial portal into the interface between the bony tunnel and the cancellous aspect of the bone block. This allowed parallel placement of the interference screw with the bone block. Firm traction was then applied to the tibial bone block while the knee was taken through a full range of motion to pretension the graft and to observe full extension without impingement. An AO 6.5-mm, fully threaded, cancellous screw was inserted as an interference screw parallel and posterior to the tibial bone block. This screw was initially advanced two to three turns while the knee was flexed. When a firm grip was obtained, the leg was straightened to ensure full extension and that the screw was fully seated. Stability was checked with the Lachman and anterior drawer tests.

If MCL repair or reconstruction was required, it was performed before final tibial fixation of the ACL graft. Acute grade 3 ruptures were repaired using a medial incision for exposure. The synovium and deep fibers of the MCL were repaired initially, followed by repair of the superficial structures. If the injury was an avulsion off the bone, staple fixation was used to secure the MCL in its anatomic position. Those knees with chronic grade 2 laxity even after ACL reconstruction were corrected by initially determining the site of laxity by clinical and arthroscopic examination. If the femoral side required tightening, an incision was made over the medial epicondyle and the MCL was advanced proximally with a bone block and stapled into position. If the tibial side was lax, then advancement and staple fixation were performed through a medial tibial incision. The ACL reconstruction was then completed by securing the tibial bone block with an interference fit screw.

The knee joint was then thoroughly irrigated and small suction drains were placed—one intraarticularly and the other draining the subcutaneous tissues. Bone block defects were filled with bone chips, routine closure was performed, and dressings were applied. The tourniquet time averaged 76 (±17) minutes. The shortest tourniquet time was 43 minutes and the longest was 135 minutes. The surgical time was generally 10 minutes shorter than the tourniquet time.

In 1989, the postoperative regimen and rehabilitation consisted of the following. For the first 24 hours the patient's leg was placed in a continuous passive motion machine with 30° to 90° of motion allowed. At 24 hours, the leg was placed in a rehabilitative brace allowing 30° to 90° of motion. The patient was nonweightbearing and on crutches for 4 weeks. Intravenous floxacillin and gentamicin were used for 24 hours and were discontinued when the drains were removed on the 1st postoperative day. In addition to the femoral nerve block, pain control was achieved with narcotics; the patient was on oral analgesics at the time of discharge. The average time of hospital stay was 2.5 days. The usual clinical followup included review at 10 to 14 days for wound inspection and suture removal. The patient was seen at 6 weeks, 3 months, 6 months, and then on a yearly basis. Aggressive physical therapy and mobilization were undertaken at 4 weeks to achieve a full range of motion and adequate muscular strength. Return to competitive sports involving jumping, pivoting, or sidestepping was allowed no sooner than 9 months after reconstruction. The postoperative rehabilitative regimen was similar for those patients who underwent meniscal repair or MCL reconstruction.

Follow-up Evaluation

All patients were evaluated retrospectively at 1 and 5 years by independent examiners. At the 1-year review, all patients completed a Lysholm knee score[47] and activity levels were recorded. A clinical examination was conducted on each patient. Ligament stability was measured with manual testing including the Lachman, anterior drawer, and pivot shift tests. The Lachman and anterior drawer tests were graded as 0 (<3 mm of laxity), 1 (3 to 5 mm of laxity), 2 (6 to 10 mm of laxity), or 3 (>10 mm of laxity). The pivot shift was graded as 0 (no pivot), 1 (glide), 2 (pivot shift), or 3 (dramatic pivot shift that requires the examiner to ease off on the force applied to allow reduction of the knee). Medial collateral ligament laxity was documented using a valgus force with the knee in 20° of flexion. Laxity was graded as 0 (<3 mm), 1 (3 to 5 mm), 2 (6 to 10 mm) or 3 (>10 mm). Range of motion (flexion and extension) was measured with a goniometer. Quadriceps muscle atrophy was determined by measuring the difference in quadriceps muscle circumference 10 cm above the superior pole of the patella as compared with the opposite leg. Joint tenderness was elicited by direct palpation, and the site of pain was recorded. The severity of pain was not recorded.

The 5-year assessment included a modified version of the IKDC Knee Ligament Standard Evaluation. This evaluation was composed of seven criteria: 1) subjective assessment, 2) symptom evaluation (pain, swelling, partial and full giving way), 3) range of motion (flexion and extension), 4) ligament evaluation (Lachman, anterior drawer, medial joint opening, and pivot shift tests), 5) compartment crepitus (medial, lateral, and patellofemo-

ral), 6) radiographic evaluation (weightbearing AP, 30° AP, lateral, tunnel, and skyline views), and 7) single-legged horizontal hop test (distance compared with opposite leg).

Each of these seven groups was assigned one of four grades: normal (A), nearly normal (B), abnormal (C), or severely abnormal (D). An overall grade, the "Standard Evaluation" consisted of the lowest score awarded in any of the seven groups.

The Lysholm knee score[47] and IKDC activity levels were also recorded. Those patients who were participating at level III or IV were asked to document why they were not participating at a higher level. Quadriceps muscle atrophy was determined as described earlier. Pain on kneeling was assessed by recording the location of the pain and, if present, rating it on a scale of 1 to 10, where 10 is severe pain.

Statistical Methods

For the statistical analysis, the primary demographic variables (sex, age [under or over 30], injury phase [acute, subacute, chronic], and preinjury activity level [I, II, or III]) were regarded as independent variables. The secondary demographic variables (meniscectomy, concurrent MCL repair, and the presence of articular surface damage) were tested individually for a dependence on the primary demographic variables using logistic regression with the SAS LOGISTIC procedure (SAS Institute, Inc., Cary, North Carolina).[40]

Dependence of outcome variables, clinical and radiographic, on the primary and secondary demographic variables was also assessed using logistic regression. Associations among the outcomes variables were quantified as Kendall's tau-b using the SAS CORR procedure.[41] Friedman's nonparametric test was used to test for changes in outcome variables over time. Multiple comparisons between specific time points were performed as described by Conover.[15] The significance level was chosen to be $P < 0.05$.

RESULTS

Results are reported for 65 of 68 patients because 3 patients subsequently ruptured their ACL grafts before completion of the 5-year review.

Demographics

A significant predictor of meniscectomy (either medial or lateral) was the time between injury and reconstruction ($P < 0.01$); meniscectomy was more likely if the injury was chronic than if it was acute or subacute. There were no significant differences found between the clinical results and the demographic variables of age, sex, preinjury activity level, and concurrent MCL surgery.

IKDC Knee Ligament Standard Evaluation

Subjective Assessment. Before the ACL injury, 59 patients (87%) thought their knees were normal. The remaining nine patients (13%) considered the knee to be nearly normal. Of the 65 patients reviewed 5 years postoperatively, 29 (45%) considered their knees to be normal, 34 (52%) considered their knees to be nearly normal, and 2 (3%) assessed their knees as abnormal. No patient assessed his or her knee as severely abnormal.

Symptoms. The absence of pain, swelling, or giving way was assessed as normal. At 5 years, 36 patients thought that in the symptom category their knees were normal, 28 rated their knees as nearly normal, and 1 patient rated the knee as abnormal. Knee pain during activity was more common in those patients who had meniscectomy at the time of ACL reconstruction ($P < 0.05$) and in those patients with patellofemoral crepitus ($P < 0.01$).

Range of Motion. At 5 years, 48 patients (74%) had full extension and 14 patients (21%) lacked 3° or less. Two patients were lacking 4° to 5°, and one patient was lacking 9°. This was an improvement from the 1st year, when four patients lacked between 5° to 10° of extension. Fifty patients (77%) had full flexion at 5 years, and the remaining 15 patients (23%) were lacking less than 10°. These results were not significantly different from the results at 1

TABLE 2
Pre- and Postoperative Results for the Lachman and Pivot Shift Tests[a]

IKDC rating	Grade	Preoperative ($N = 68$)				Postoperative ($N = 65$)			
		Total	A	SA	C	Total	A	SA	C
					Lachman				
A	0	0	0	0	0	42	13	8	21
B	1	5	3	1	1	22	9	3	10
C	2	50	19	8	23	1	0	0	1
D	3	13	2	2	9	0	0	0	0
					Pivot shift[b]				
A	0	0	0	0	0	52	16	10	26
B	1	15	9	3	3	12	6	1	5
C	2	43	12	7	24	1	0	0	1
D	3	6	0	1	5	0	0	0	0

[a] A, acute; SA, subacute; C, chronic.
[b] Four patients had locked knees and could not perform the pivot shift test (three acute and one chronic).

year. There was no correlation between the amount of extension loss and any of the clinical test results at 5 years.

Ligament Examination. The results of preoperative and postoperative manual ligament stability testing are shown in Table 2. These results at 5 years were not significantly different from those at 1 year. Of the six patients with nonoperatively treated MCL injuries, all six had grade 0 to 1 laxity. Of the 13 patients who had MCL surgery, 11 had grade 0 to 1 laxity and 2 had grade 2 laxity. Although patients in the subacute injury group scored the best results, there were no statistically significant differences between patients with acute, subacute, or chronic injuries.

Compartment Findings. Compartment testing for crepitus at 5 years revealed that 22 patients (34%) had patellofemoral crepitus, 13 (20%) had medial compartment crepitus, and 9 (14%) had lateral compartment crepitus. Those patients with patellofemoral crepitus were shown to have more knee pain with activity, a lower activity level, experienced more partial giving way, and subjectively felt that their knee was worse ($P < 0.01$). It is likely that the sensation of partial giving way is related to "buckling," which is common in patients with patellofemoral symptoms.

Radiographic Evaluation. Radiographic evaluation included weightbearing AP and 30° flexion AP views as well as lateral, tunnel, and skyline views of the affected knee. Radiographs were obtained on 62 patients. Three patients did not follow up with the radiographic request, and we were unable to contact them further.

Forty-seven patients had normal radiographs (IKDC type A) (Table 3). Seven had early degenerative changes (femoral condylar flattening, subchondral sclerosis, osteophytes) but no joint space narrowing (IKDC type B). Six patients had joint space narrowing estimated at less than 50% of the joint height (IKDC type C), and two patients had joint space narrowing of more than 50% of the joint height (IKDC type D).

Degenerative joint disease was more common in patients with chronic ACL-deficient knees, those who had had a meniscectomy, and those with arthroscopic evidence of degeneration at the time of ACL reconstruction ($P < 0.05$).

There were 28 patients in this study who were free of meniscal or chondral damage at the time of ACL reconstruction. At 5 years, two of these had early degenerative changes evident on radiographs classified as IKDC type B. Twenty-six of these patients had normal radiographs, classified as IKDC type A.

Functional Tests. Two patients were unable to complete the single-legged hop test because of other injuries. Of the 63 patients who completed the single-legged hop test, 60 (95%) were able to hop 90% to 100% of the distance of the opposite leg (IKDC rating A). The remaining three patients hopped 75% to 89% of the distance (IKDC rating B).

Overall IKDC Rating. The overall rating was determined from the lowest grade of the above seven groups and is shown in Table 4. The two patients rated as severely abnormal had joint space narrowing of more than 50%. Of the 11 patients rated as abnormal, 6 had joint space narrowing of less than 50%, 2 had abnormal crepitus, 2 subjectively scored their knees as abnormal, and 1 had abnormal loss of motion. Although patients in the subacute injury group scored the best results, there were no statistically significant differences between patients with acute, subacute, or chronic injuries.

Quadriceps Muscle Atrophy

Sixty patients (92%) had full quadriceps muscle bulk or had 1 cm or less difference between the injured and noninjured limb. There were four patients with 1- to 2-cm differences, and one patient had a 3-cm difference in quadriceps muscle circumference. There was less quadriceps muscle atrophy at 5 years than at 1 year postoperatively ($P < 0.05$), and there was no correlation between the amount of quadriceps muscle atrophy and any of the clinical test results at 5 years. Although patients in the subacute injury group scored the best results, there were no statistically significant differences between patients with acute, subacute, or chronic injuries.

Tenderness/Kneel Test

At 1 year, tenderness was elicited by direct palpation over the knee. Of the 64 patients evaluated, 30 patients (47%) had palpable tenderness over the graft harvest site, 1 patient had medial joint pain, and 1 had lateral joint pain. Thirty-two patients (50%) had no palpable tenderness.

At 5 years, 52 patients (80%) had no pain while kneeling on the reconstructed knee. Eleven (17%) patients had anterior pain (patella, patellar tendon, and tibial tubercle), one patient had deep pain, and one had medial pain. The average score for severity of pain (on a scale of 1 to 10) was 2 ± 2, with a range of 1 to 6. Three patients had moderate levels of pain (4 to 6). Patients with pain on kneeling were more likely to give themselves a lower score on the IKDC subjective assessment ($P < 0.05$). Although patients in the subacute injury group scored the best

TABLE 3
Radiographic Results at 5 Years ($N = 62$)

IKDC rating	Total	Group		
		Acute	Subacute	Chronic
A	47	18	10	19
B	7	2	0	5
C	6	1	0	5
D	2	0	0	2

TABLE 4
Overall IKDC Assessment Results ($N = 65$)

IKDC Rating	Total	Group		
		Acute	Subacute	Chronic
A	14	5	4	5
B	38	13	7	18
C	11	4	0	7
D	2	0	0	2

results, there were no statistically significant differences between patients with acute, subacute, or chronic injuries.

Activity Level

The preinjury ratios for activity level were not restored at 1 or 5 years after reconstruction. Sixty-six patients (97%) participated in level I or II activities before injury, only 52 patients (74%) achieved this at 1 year, and 50 patients (77%) at 5 years after surgery. There were significantly more people performing level I activities at 5 years than at 1 year ($P < 0.01$), and older patients were more likely to have a lower activity level ($P < 0.05$). Although patients in the subacute injury group scored the best results, there were no statistically significant differences between patients with acute, subacute, or chronic injuries.

Of the 15 patients participating in level III or IV activities at 5 years, 13 were reached for further questioning. Ten people had lowered their activity levels because of life-style changes, three people had other injuries limiting their activity, and only one patient stated that her knee was the limiting factor in her return to a higher level.

Further evaluation at 5 years revealed that 25 patients (38%) were able to return to the same preinjury level of activity, 10 patients (15%) were able to return to a higher level, and 30 patients (47%) were performing at a lower level of activity.

Lysholm Knee Score

The average Lysholm knee score was 89 of 100 at 1 year and 91 of 100 at 5 years. Fifty-nine patients (91%) had a score of more than 77 at 5 years. Although patients in the subacute injury group scored the best results, there were no statistically significant differences between patients with acute, subacute, or chronic injuries.

Complications and Subsequent Surgery

Three patients reruptured their ACL grafts before the completion of the 5-year study. Reruptures occurred at 29, 44, and 56 months from the time of ACL reconstruction. Two patients reruptured their grafts while sidestepping during sporting activities, and the third patient fell off a horse. Before their reruptures, all patients had stable joints and had returned successfully to competitive sports. Three patients required a manipulation under anesthesia, and one had arthroscopic division of adhesions to restore motion. These were all patients who had undergone acute reconstructions. Four patients had protruding tibial screws that required removal. Two patients underwent subsequent partial medial meniscectomy after experiencing twisting injuries. Both patients had normal menisci at the time of reconstruction and had ligamentous stability at their last review. There were no clinical failures of any of the menisci that were sutured at the time of reconstruction. One patient developed a septic arthritis that was treated with arthroscopic lavage, removal of the screws, and intravenous antibiotics. The treatment was effective and the joint remained stable.

DISCUSSION

An ideal ACL reconstruction should restore normal knee mechanics and stability, allowing patients to return to their previous functional levels. There should be a low incidence of recurrent meniscal injury and a decreased risk of traumatic degenerative arthritis. Ensuring anatomic graft placement is probably the most important factor within the surgeon's control that will ensure a successful outcome. The single-incision technique used in this study allows easy visualization of the femoral and tibial graft insertion sites with the arthroscope.

Restoration of stability is the first objective in ACL reconstruction, and this study demonstrated that the single-incision technique with patellar tendon autograft and interference screw fixation gave good stability at 1 year with no deterioration after 5 years. At 5 years, we had 98% of 65 patients with 5 mm or less of laxity on Lachman testing, 80% with negative pivot shift results, and 18% with grade 1 pivot shift results. Our results are comparable with those from similar studies using one- or two-incision arthroscopic techniques with patellar tendon autograft. Bach et al.[5] reported on 103 patients with a single-incision technique and minimum 2-year followup. They noted 98% with 5 mm or less laxity on Lachman testing, 91% with negative pivot shift results, and 9% with grade 1 pivot shift results. Bach et al.[6] also reported on 97 patients with a two-incision technique and a minimum 5-year followup. They noted 98% with 5 mm or less laxity on Lachman testing, 84% with negative pivot shift results, and 16% with grade 1 pivot shift results.

Once knee stability has been achieved, the next objective is to return patients to their preinjury levels of activity. In this study, 53% of patients were able to return to their preinjury levels of activity or higher, and 77% were performing IKDC level I or II activities. We found, as several other authors have, that many patients lowered their activity level because of changes in life-style not related to the knee.[4-6,12,14,16,35,42]

In the literature, there has been a lack of documentation that reconstructing an ACL-deficient knee prevents arthritic changes. Most studies, and ours is no exception, have been laden with patient populations consisting of chronic ACL-deficient knees.[4-6,12,16,34] Many of these knees required meniscectomies and this can, in part, explain the increased incidence of the degenerative joint disease reported in reconstructed knees.[18] In this study, 24% of patients demonstrated radiographic evidence of deterioration 5 years after reconstruction. We have shown that the majority of these patients had chronic ACL-deficient knees that required meniscectomies and already had arthroscopic evidence of degeneration at the time of reconstruction. Because arthroscopic findings appear to correlate closely with radiographic findings,[16] it is likely that many of these patients had radiographic degenerative changes before their reconstructions. In a study of 97 patients with a two-incision technique and minimum 5-year followup, Bach et al.[6] noted minimal degenerative changes on radiographs. They reported an average score of 17.1 of 18 (range, 12 to 18) on the degenerative part of the

Hospital for Special Surgery ACL radiographic score. They did not mention if worse degeneration was seen in knees with chronic ACL injuries or meniscectomies.

In the 28 patients free of meniscal or chondral damage at the time of their ACL reconstructions, 2 had early degenerative changes on radiographs at 5 years. Degenerative changes have previously been documented in patients with ACL reconstructions and no meniscectomy. Daniel et al.[16] stated five reasons why arthritis could be more common in a reconstructed knee: 1) greater injury before surgery, 2) joint injury at the time of the surgery, 3) response to stress deprivation after surgery, 4) prolonged joint inflammation, and 5) abnormal joint mechanics after surgery. It is somewhat encouraging that 26 of the 28 patients with normal menisci and chondral surfaces had normal radiographs at 5 years, and this clearly emphasizes the importance of preserving the meniscus when treating ACL-deficient knees.

Persistent problems associated with ACL reconstruction using autogenous patellar tendon graft include fixed flexion contracture, patellofemoral pain symptoms, graft site pain, and quadriceps muscle atrophy.

Patients did well to recover their range of motion in this study, particularly in view of the postoperative rehabilitation program, which did not allow full extension for 4 weeks after reconstruction. Only three patients were lacking more than 3° of extension 5 years after their reconstructions. We now use an aggressive rehabilitation program with early full range of motion similar to that described by Shelbourne and colleagues.[43,44] We are now more conservative in treating concurrent grade II MCL injuries. Several authors have noted that flexion contracture can be decreased if surgery is delayed for 3 to 4 weeks after ACL rupture.[21,43] Although we observed no statistically significant differences between the groups with acute, subacute, and chronic injuries, we did have to perform four reoperations to restore motion in the acute injury group. Presently, we prefer to delay reconstruction until the patient has restored nearly normal range of motion with minimal swelling.

The problem of patellofemoral pain symptoms after ACL reconstruction is complex and can be related to many factors.[1,4,39,46] Some of these factors include poor preoperative range of motion, preexistent patellar chondromalacia, postoperative immobilization, inadequate or inappropriate rehabilitation, fixed flexion contracture, pain from the graft harvest site, and violation of the extensor mechanism. It is difficult to compare results from different studies because they use different surgical techniques, rehabilitation protocols, and methods of assessing patellofemoral symptoms. Buss et al.[12] documented patellofemoral symptoms in 23% of their patients with ACL deficiency. They also noted a 26% incidence of symptoms in 68 knees undergoing two-incision arthroscopically assisted reconstruction using patellar tendon graft. Bach et al.[6] in their study with a two-incision technique and minimum 5-year followup reported 45% of 97 patients had patellofemoral crepitus and 13% had discomfort climbing stairs.

At 5 years after surgery, many patients (44.5%) still had low levels of knee pain when performing at their highest functional level. Although we did not determine the exact cause of this pain, we did find that these patients were more likely to have patellofemoral crepitus, a meniscectomy, or both. Many patients (17%) continued to have pain at their graft harvest site. This was an important problem for these patients; they rated their knee lower on the IKDC subjective assessment rating.

Quadriceps muscle atrophy was still present in many patients (35%) at 5 years' followup, even though this was not found to correlate with any other clinical results. It is somewhat troubling that 8% of patients still have more than 1 cm of thigh circumference atrophy at 5 years. Bach et al.[6] reported 26% of 97 patients had greater than 1 cm thigh atrophy after a minimum followup of 5 years. Those patients had reconstructions with a two-incision technique.

In summary, ACL reconstruction using a single-incision arthroscopic technique with patellar tendon autograft resulted in excellent ligamentous stability allowing most patients to return to a high level of function. Eighty percent of knees were scored normal or nearly normal on the IKDC evaluation. Radiographic deterioration was common in patients with chronic ACL-deficient knees and was uncommon in patients with intact menisci. Knee pain with functional activity and palpable tenderness over the graft site remains a problem in many patients. We would expect even better results with new advances in surgical technique and postoperative physical therapy.

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