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Arthrofibrosis in acute anterior cruciate ligament reconstruction

The effect of timing of reconstruction and rehabilitation

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ABSTRACT

Arthrofibrosis is a potential complication of acute ACL reconstruction. Arthrofibrosis prevents the patient from regaining full range of motion, particularly the terminal 5° of full extension, postoperatively. We did a retrospective study of 169 acute ACL reconstructions in a population of young athletes (average age, 22 years). We sought to determine the optimal time to perform acute ACL reconstruction with respect to arthrofibrosis and the effects of an accelerated versus conventional rehabilitation program. The short-term results were evaluated by range of motion measurements and 13 week Cybex scores. Patients whose ligaments were reconstructed within the 1st week after injury (Group I) had a statistically significant ($P < 0.05$) increased incidence of arthrofibrosis (limited extension, scar tissue) over patients who had ACL reconstruction delayed 21 days or more (Group III). At 13 weeks after the reconstruction procedure, Group III patients scored an average of 70% (compared to 51% for Group I, $P < 0.05$) on the Cybex evaluation. They also showed a trend toward more flexion of the knee as well as near full extension. Patients who had an ACL reconstruction between 8 and 21 days after injury (Group II) had a similar incidence of arthrofibrosis as Group I when they followed a conventional rehabilitation program postoperatively. However, only a small number of cases (approximately 4%) of Group II patients who followed an accelerated postoperative rehabilitation program had any arthrofibrosis—an observation we also made in the Group III patients. The evidence suggests that delaying reconstructive surgery at least 3 weeks from time of acute ACL injury will result in earlier return of strength and, more importantly, a significantly decreased incidence of arthrofibrosis.

Recent clinical research has demonstrated the efficacy of reconstructing the acutely torn ACL in athletes. Even as the outcome of the procedure has become more predictable, orthopaedic surgeons and therapists realize that joint stiffness still remains the single most common complication following surgical intervention.[5, 6, 9, 12, 17]

Arthrofibrosis, also referred to as ankylosis, joint stiffness, and flexion contracture, represents a significant problem in the knees of high-demand, young, athletes.[9] While the stiff athletic knee is stable by all objective orthopaedic criteria, it has been our experience that patients who fall into this category are seldom completely satisfied with the function of their knee upon return to competition.

In the evolution of ACL surgery, several developments are of special interest in regards to improvements in knee motion,[2, 11, 12] specifically that of full extension.[15] Improved surgical techniques, with particular emphasis on proper graft placement, along with adequate notchplasty, have eliminated the impingement of the graft itself, thus allowing full extension.[1, 3, 5, 6] Furthermore, improved graft fixation techniques, along with early motion, have also eliminated the need for immobilization, which can be considered one cause of postoperative joint stiffness.[12, 14, 18] Finally, using an aggressive accelerated rehabilitation program that emphasizes full passive extension, muscle control, management of swelling, early motion, and functional exercise, has demonstrated improved knee function over more conventional protocols.[7, 8, 16]

The bone-patellar tendon-bone autograft has been labeled the "gold standard" for ACL reconstruction.[4] With increased awareness of arthrofibrosis and the infrapatellar contracture syndrome, there may be a theoretical advantage of using a

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semitendinosus autograft, an allograft, or a prosthetic ligament, even though patellar tendon grafts result in excellent strength, stability and long-term effectiveness.[6,9,13] Although the etiologies of arthrofibrosis are presently not well-defined, there is documented evidence of an increased incidence of the problem in the acutely reconstructed ACL, as compared to reconstruction accomplished in the chronic ACL deficient knee.[10] Our previous studies have shown that reconstruction of the chronic ACL had similar KT-1000 measurements and subjective results as those that have been acutely reconstructed.

The prospect of the study raised three questions. First, since chronic ACL reconstructions have less arthrofibrosis than acute reconstructions as determined by postoperative motion, when does an acute ACL reconstruction behave like a chronic ACL? Second, can surgical intervention be optimally timed to minimize the incidence of arthrofibrosis, yet still be performed before there is an increased incidence of irreparable meniscal or chondral abnormality? Finally, does the timing of surgery affect not only ultimate range of motion, but early Cybex scores?

The purpose of this study was to review our experience of reconstructing the acutely torn ACL, with a focus on comparing the timing of surgery from the date of injury with the incidence of arthrofibrosis.

MATERIALS AND METHODS

A total of 213 consecutive patients with acute tears of the ACL comprised the population of this retrospective 3 year study conducted at our institution from 1986 through 1988. Of these 213 patients, 169 had preoperative and postoperative evaluations of range of motion, laxity, and strength measurements for inclusion in the study. All patients had reconstruction of the ACL within 8 weeks after their ACL injury. It was stipulated that no attempt should be made to return to full activity before the surgical reconstruction. All patients were treated by the same surgeon and had the same ACL reconstruction (bone-central third patellar tendon-bone, via arthrotomy, with button fixation, excision of the ACL stump, and adequate notchplasty). Full flexion and extension were achieved at the time of surgery. The patients from 1986 followed a conventional postoperative rehabilitation program (Table 1). The patients reconstructed in 1987 through 1988 followed an accelerated postoperative rehabilitation protocol (Table 2).

The study population (112 males and 57 females) had an average age of 22 years (range, 13 to 46). It was our initial belief that immediate surgery on the acutely torn ACL would obtain better results. Operative candidates had been encouraged to have surgery as soon as possible after their initial injury. Patients with more severe injuries (additional ligament injuries) were especially encouraged to have an immediate reconstruction. We were concerned that delaying surgery for a short period of time after the injury would lead to increased difficulty obtaining postoperative motion and strength. Because a substantial number of our patients were high school-aged athletes, college recreational athletes, and career recreational athletes, many still elected to delay surgery to accommodate academic or personal priorities. Professional athletes and college athletes with scholarships tended to have surgery immediately. Thus, the study population was divided into three groups. Group I consisted of 33 patients who had surgery between 0 to 7 days from the time of injury; Group II consisted of 65 patients who had surgery 8 to 21 days from the time of injury; and Group III consisted of 71 patients who had surgery more than 21 days after injury.

Since Groups I and II demonstrated more motion problems than Group III, Groups I and II were additionally subdivided by postoperative program. Patients who participated in the conventional rehabilitation program were further identified as "A." Those in the accelerated protocol were labeled as "B."

All associated injuries to the knee were recorded. These included lateral and medial meniscus tears, and medial and lateral collateral ligament tears. Posterior cruciate ligament injuries were not included in the study. Unstable meniscal tears were repaired whenever possible. Any torn medial collateral ligament was not repaired, while the torn lateral

TABLE 1
Conventional rehabilitation program

Date after surgery	Treatment
2–3 days	CPM[a]
	Passive ROM 0–60°
	Partial weightbearing with crutches and splint
4 days	Discharge from hospital
1–2 weeks	ROM 0–90°
	Wall slides, heel slides, straight leg raises
	Step-ups, calf raises
	Partial weightbearing
3–4 weeks	ROM 0–100°
	Prone hang for terminal extension
	Full weightbearing
	Unilateral knee bends, step-ups, calf raises
	Partial squats, biking (no tension)
5–6 weeks	ROM—terminal extension to 120°
	Prone hangs
	Partial squats, leg press, calf raises
	Biking, swimming
10–12 weeks	ROM—terminal extension to 130°
	Isokinetic evaluation with 20° block at 180 and 240 deg/sec
	Partial squats, leg press, biking with moderate resistance
	Jump rope
4 months	Full ROM
	Isokinetic evaluation at 60, 180, 240 deg/sec
	Continue with strengthening, biking, swimming
	Functional progression if strength 70%
6 months	Isokinetic evaluation, KT-1000
	Increase agility

[a] Continuous passive motion.

TABLE 2
Accelerated rehabilitation program

Date after surgery	Treatment
2–3 days	CPM[a]
	Passive ROM exercise for terminal extension and 90° flexion
	Weightbearing as tolerated
3–4 days	Discharge from hospital
7–10 days	ROM—terminal extension
	Prone hangs and towel extensions
	Wall slides, heel slides, active-assisted flexion
	Strengthening—knee bends, step-ups, calf raises
	Partial to full weightbearing
2–3 weeks	ROM—terminal extension to 110°
	Unilateral knee bends, step-ups, calf raises
	Weight room activities: leg press, quarter squats and calf raises in the squat rack
	Bicycling, swimming
5–6 weeks	ROM—terminal extension to 130°
	Isokinetic evaluation with 20 degree block at 180 and 240 deg/sec
	If greater than 70%, start lateral shuffles, cariocas, and jumping rope
	Continued weight room activities
	Continue bicycling and swimming
12 weeks	Full ROM
	Isokinetic evaluation at 60, 180, and 240 deg/sec
	KT-1000
	Increased agility workouts
16 weeks	Isokinetic evaluation, KT-1000
	Increased agility workouts

[a] Continuous passive motion.

TABLE 3
Associated injuries to the knee

Group	N	Isolated ACL[a]		ACL and meniscus tear[b]		ACL and repairable meniscus tear		ACL and other ligament injury	
		N	(%)	N	(%)	N	(%)	N	(%)
IA	26	4	(15.4)	19	(73.1)	8	(30.8)	6	(23.1)
IB	7	1	(14.2)	5	(71.4)	1	(14.3)	3	(42.8)
	33	5	(15.1)	24	(72.7)	9	(27.3)	9	(27.2)
IIA	46	12	(26.1)	28	(60.9)	9	(19.6)	15	(32.6)
IIB	19	5	(26.0)	10	(52.6)	3	(15.8)	3	(15.8)
	65	17	(26.1)	38	(58.5)	12	(18.5)	18	(27.7)
III	71	22	(31.0)	48	(67.6)	26	(36.6)	2	(2.8)

[a] No additional meniscal, ligament, or chondral injury.
[b] Torn but stable; repairable and irreparable.

complexes were repaired anatomically. These injuries are summarized in Table 3.

Patients were seen postoperatively by the surgeon at 1 week, 2 weeks, and 5 weeks, and every month thereafter. Objective evaluations consisted of Cybex scores at 5 weeks and monthly thereafter. Cybex scores at 13 weeks were compared at 180 deg/sec. Range of motion (ROM) was recorded as A, B, and C with A as hyperextension, B as degrees short of 0° of extension, and C as flexion. Additionally a KT-1000 examination was done at 5 weeks and each followup thereafter. KT-1000 readings at final followup were recorded for analysis.

RESULTS

Linear regression analysis was used to evaluate the data and compare the study groups. Analysis of the Cybex scores at 13 weeks revealed that Group III patients scored significantly higher than Group I (Table 4). At 13 weeks, the percentage of patients with a 60% Cybex score showed a trend indicating that delayed surgical intervention was beneficial (Table 4).

The ROM scores (hyperextension, extension, flexion) showed a trend toward Group III being the most successful in regaining early flexion ($P > 0.10$) and lacking the least extension of any group at a specific test date ($0.05 < P < 0.10$; Table 4). No patient in our study lacked 10° or more of full extension. The percentage of each population lacking 5° of full extension showed Group III again as most successful ($P < 0.05$; Table 4).

Because of differences in rehabilitation programs, Groups I and II were further analyzed and divided into 1986 (A) and 1987 to 1988 (B) subgroups. The 1987 to 1988 subgroups for Groups I and II showed a lower percentage of their population lacking 5° of full extension (Table 5). No patient in Group IIB or in Group III lacked 5° of full extension (Table 5). Following a conventional program, patients exhibited a statistically higher incidence of arthrofibrosis ($P < 0.001$; Table 4).

Even with our strict criterion of lacking 5° of full extension as an acceptable objective result, some patients remained symptomatic, with "stiffness" being the chief complaint. An arthroscopic scar resection, with particular attention paid to the notch and anterior knee, was offered as a treatment option. All patients undergoing scar resection were subjectively and objectively improved. Group I had the largest percentage of patients undergoing scar resection. Additional analysis revealed that there were no significant differences in stability as measured by KT-1000 maximum manual testing. Group I had an average KT-1000 reading of 1.8 mm as compared to 2.0 mm for Group II and 1.7 mm for Group III.

DISCUSSION

The purpose of this study was to identify an optimal time to perform a primary intraarticular patellar tendon autograft in knees with acutely torn ACLs in the hopes of minimizing the surgical complication of arthrofibrosis, or the stiff knee. While the etiology of arthrofibrosis is multifactorial, our study suggests that the timing of surgery from initial injury is a critical determinant.

No patient in Group III, regardless of postoperative rehabilitation program, lacked more than 5° of full extension. At 3 weeks, muscle control had returned, swelling had subsided, and ROM was improving. Conversely, the 1st week following injury, the acutely torn ACL knee has limited

TABLE 4
Evidence of arthrofibrosis in 169 knees

Group	13 week Cybex score 180 deg/sec[a]	Patients with 60% Cybex score[b] (%)	Modified Noyes questionnaire scores	ROM mean score Flexion[c] to hyperextension[d]	% Patients with 5° extension loss[e]	Scar resections[f] (%)
I	**51**	**63**	89	122 to +1.8	**17**	**12.5**
II	**66**	**77**	84	123 to +1.2	11	**4.6**
III	70	79	88	127 to +2.4	0	4.2

[a] $P < 0.05$ ($P = 0.019$).
[b] $P > 0.10$ ($P = 0.6067$).
[c] $P > 0.10$ ($P = 0.236$).
[d] $0.05 < P < 0.10$ ($P = 0.055$).
[e] $P < 0.05$ ($P = 0.014$). See Table 5 for comparison of evidence of arthrofibrosis in Groups IA and IIA who participated in a conventional rehabilitation program and Groups IB and IIB who participated in an accelerated rehabilitation program.
[f] $P > 0.10$ ($P = 0.219$).

TABLE 5
Subgroups by year of surgery

Group[a]	ROM[b]
IA	33
IB	7
IIA	38
IIB	0

[a] Group I: 1986 vs. 1987–1988, $P > 0.10$ ($P = 0.1162$). Group II: 1986 vs. 1987–1988, $P < 0.001$ ($P = 0.003$). 1987–1988: I vs. II, $P > 0.10$ ($P = 0.3019$).
[b] Percentage of each subgroup lacking 5° of full extension at 13 weeks.

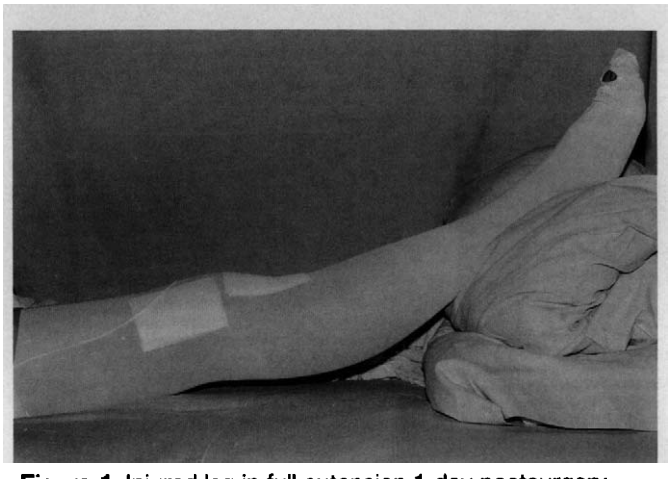

Figure 1. Injured leg in full extension 1 day postsurgery.

ROM, particularly that of extension, a moderate hemarthrosis, and quadriceps inhibition. Despite our accelerated rehabilitation, 7% of patients in Group I still developed arthrofibrosis.

In our study, the accelerated rehabilitation program completely eliminated significant arthrofibrosis in Group II patients. This was statistically significant ($P < 0.001$). In Group I patients, the accelerated rehabilitation program showed a trend toward decreased joint stiffness ($P > 0.010$). The accelerated rehabilitation program emphasized full passive extension (Fig. 1), cryotherapy, early muscle control, early motion, and functional exercise including immediate weightbearing. We are of the opinion that all of these rehabilitation principles contribute to the reduction of the incidence of arthrofibrosis.

Closer review of the associated injuries revealed that, while there were a similar number of meniscal injuries, there were a significantly increased number of additional ligament injuries in Groups I and II. Initially, we felt that these additional ligament injuries might contribute to the incidence of arthrofibrosis. However, each of the six patients with additional ligament injuries in Group IA maintained early full extension and did not require arthroscopic scar resection. Nonoperative treatment of concomitant injuries did not increase the incidence of arthrofibrosis. Additionally, our data suggests that meniscus repair by itself was not a risk factor in the development of a stiff knee. Group III had the highest incidence of meniscus repairs and the lowest incidence of arthrofibrosis.

Furthermore, delaying surgery did not adversely affect other early objective results. In fact, there was a trend toward earlier return both of strength and flexion. Contrary to our initial belief, delaying surgery instead of immediate surgical intervention achieved better results. There was no effect on stability as measured by the KT-1000.

It is important to stress that any delay in reconstruction should not be thought of or used as idle time for the patient. Preoperative physical therapy, emphasizing the same principles as those used postoperatively, are extremely helpful in obtaining a good result. Additionally, we have observed psychologic changes in the athlete during this delay from injury resulting, in our opinion, in an improved attitude toward reconstruction and rehabilitation.

Delaying the procedure can provide the surgeon with an opportunity to optimize available resources and abilities. If magnetic resonance imaging or addition studies are needed, they can be scheduled during the intervening weeks. These weeks also are beneficial should further patient counseling be indicated.

Arthrofibrosis, while having many causes, appears to be a preventable complication. Contrary to our initial surgical biases, the optimal time to reconstruct the acutely injured ACL is not immediately after injury. At 3 weeks from injury, the acutely injured ACL knee begins to behave like a chronic ACL deficient knee without the irreparable damage of the

chronically unstable knee. This appears to be the minimal safe and optimum time to do a primary reconstruction. If surgery must be performed sooner than 3 weeks after the injury, an accelerated rehabilitation program emphasizing early range of motion, especially full extension, decreases the risk of developing arthrofibrosis.

CONCLUSIONS

We studied 169 cases of acutely torn ACLs that were reconstructed with intraarticular central third patellar tendon autograft. We found that delaying the reconstruction by at least 3 weeks resulted in a significant decrease in the incidence of arthrofibrosis and, more specifically, decreased the lack of full extension. An accelerated postoperative rehabilitation program can significantly decrease the incidence of arthrofibrosis in knees that are reconstructed sooner than 3 weeks after injury. Delaying surgery does not adversely affect, but actually gives improved results when compared with those of ACLs that have been reconstructed at the acute stage.

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