

# The Effect of Immediate Weightbearing After Anterior Cruciate Ligament Reconstruction

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Immediate weightbearing has been advocated after anterior cruciate ligament reconstruction and is thought to enhance the return of quadriceps muscle activity and knee extension range of motion without jeopardizing graft integrity. This study examined the effect of immediate weightbearing after anterior cruciate ligament reconstruction on the return of vastus medialis oblique electromyography activity, knee extension range of motion, knee stability, physical examination, Lysholm score, and anterior knee pain. Forty-nine patients (24 men and 25 women) undergoing endoscopic central third patella tendon autograft reconstruction were randomized prospectively into two groups. Group 1 patients underwent immediate weightbearing as tolerated. Group 2 patients were kept nonweightbearing for 2 weeks. All measurements were taken before surgery, 2 weeks after surgery, and between 6 and 14 months (average, 7.3 months) followup. There was no effect of weightbearing on knee extension range of motion or vastus medialis

oblique function at followup. In addition, knee stability was not compromised after surgery. Seven of 20 (35%) nonweightbearing patients and only two of 25 (8%) immediate weightbearing patients reported anterior knee pain at followup. Overall, immediate weightbearing did not compromise knee joint stability and resulted in a better outcome with a decreased incidence of anterior knee pain.

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Initially, anterior cruciate ligament reconstruction was performed using extraarticular techniques followed by weeks of immobilization. The development of arthroscopic techniques and intraarticular reconstruction using more anatomic techniques has allowed for early motion of the knee, minimizing intraarticular adhesions without stressing the graft. Rehabilitation protocols have become more aggressive, in part because of stronger fixation techniques and bone to bone fixation.<sup>10</sup>

The status of early weightbearing and mobilization after anterior cruciate ligament reconstruction has evolved to a much more aggressive protocol. Initially, patients were placed in a full leg cast with the knee in 30° of after anterior cruciate ligament reconstruction and were not allowed to bear weight.<sup>15</sup> However, the period of protected weightbear-

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ing after endoscopic anterior cruciate ligament reconstruction varies.<sup>2,6,11,14-18,20-22,28,29</sup> Some have advocated protected weightbearing for 6 to 8 weeks after surgery, whereas others have recommended earlier weightbearing.<sup>12</sup> As recently as 1991, O'Brien et al<sup>15</sup> advocated protected weightbearing for 6 weeks after surgery. Paulos et al<sup>17,18</sup> delayed full weightbearing for 4 weeks. Shelbourne and Nitz<sup>21</sup> have advocated an advanced and accelerated protocol based on observations that patients who did not comply with the traditional postoperative restrictions had more rapid improvement without adverse results.

Knee joint effusion is common after anterior cruciate ligament reconstruction and results in reflex inhibition of the quadriceps mechanism.<sup>24</sup> Immediate weightbearing facilitates isometric activity to the muscles surrounding the joint, counteracting this inhibitory effect.<sup>26</sup> In addition to the decreased effusion and the subsequent decrease in reflex inhibition, the theorized advantages of immediate weightbearing include increased earlier articular cartilage compression and nutrition, maintenance of subchondral bone strength, and decreased peripatellar fibrosis. The disadvantages are early loss of graft fixation and subsequent instability. Certainly, more rigid graft fixation techniques have decreased this possibility.

This study evaluated, in a randomized and prospective fashion, the effect of immediate weightbearing on the anterior cruciate ligament reconstructed knee regarding range of motion (ROM), patellofemoral pain, graft integrity, and functional activity.

## MATERIALS AND METHODS

Forty-nine patients who had diagnosis of anterior cruciate ligament tear by physical examination and magnetic resonance (MR) imaging and were scheduled for a central third patella tendon autograft reconstruction were randomized prospectively into one of two groups. One surgeon (SJN) performed all cases. Group 1 patients were allowed full weightbearing immediately after their

reconstruction surgery. They were instructed to discard their crutches as soon as possible after their surgery and to bear weight as much as possible. Group 2 patients were kept nonweightbearing for 2 weeks after surgery. They were instructed not to wear a shoe to ensure their compliance. At 2 weeks, the weightbearing restriction was lifted. The presence or absence of concomitant meniscal repair did not alter group assignment in this study. In addition, patients also were grouped by time from injury to surgery. Patients who had surgery less than 2 months after injury were assigned to the acute group. The subacute group was comprised of patients who had surgery between 2 and 6 months after injury. Patients who waited 6 months or longer from the time of injury were included in the chronic group. No patient in this study had surgery within 3 weeks of the time of injury, and informed consent was obtained before surgery for all patients.

## Physical Examination

Each patient underwent physical examination by one experienced examiner. The patients were examined and graded for ROM, stability to valgus and varus stress and anterior and posterior translation, and the pivot shift test. A predetermined grading system was established for all stability tests. The varus and valgus stress test was graded as Grade 1 (0 to 5 mm), Grade 2 (6 to 10 mm), and Grade 3 (> 10 mm). The Lachman test was graded with an A for feeling a firm endpoint and B for the feeling of no endpoint. In addition to the endpoint grade, a grade of displacement was assigned to each knee with 1 indicating displacement of 0 to 5 mm; 2, 6 to 10 mm; and 3, more than 10 mm. The pivot shift phenomenon was graded as 0, negative; 1+, slip; 2+, jump; and 3, subluxation.

Patients also underwent preoperative examination by one of two experienced therapists. This examination included goniometric measurements for preoperative ROM, arthrometric knee stability testing using the KT-1000 (MedMetric Corporation, San Diego, CA), electromyography evaluation for vastus medialis oblique activity, and the Lysholm and Tegner evaluation. Patients were evaluated at 1 day and 2 weeks after surgery for vastus medialis oblique electromyography activity and knee ROM. The same examiner evaluated the same patients before and after surgery. Anterior knee pain was evaluated with questions

from the Lysholm Scale that indicated pain with ordinary exertion or stair climbing or squatting. A predetermined score of 25 was established before the study to dichotomize patients into those with and without pain at followup.

Range of motion was measured goniometrically in flexion and extension and is reported as the difference from the uninjured side. Extension past 0 was expressed as a positive number. Anterior knee stability was measured with a KT-1000 arthrometer by one of two experienced examiners. Repeat measures were made by the same examiner. The leg was tested at 20° flexion, and side to side differences were calculated for the maximum manual test.

The long sitting position with the knees fully extended was selected for electromyography testing. This position was used to minimize pain and achieve attainable knee extension during quadriceps contraction 1 day and 2 weeks after surgery, and at all followup studies. The 1-day measurement was discontinued after 25 patients because of near total absence of activity in all subjects. The unfiltered electromyography of the vastus medialis oblique was recorded at a frequency of 1000 Hz on both sides using the Noraxon Myosoft electromyography system (Noraxon USA, Inc, Scottsdale, AZ). The skin was abraded and two surface electrodes were placed over the belly of the vastus medialis oblique. The linear envelope of the rectified signal of an 8-second isometric contraction was recorded. A 5-second window spanning the area of maximum activity (total volts) was determined, and the average of the four repetitions was recorded. The activity of the involved vastus medialis oblique is expressed as the ratio of involved divided by the uninvolved multiplied by 100.

### **Surgical Technique**

Patients were administered general or epidural anesthesia (depending on their preference), and a pneumatic tourniquet and leg holder was used in every case. Patients underwent a single incision central third endoscopic anterior cruciate ligament reconstruction. A superior lateral inflow portal was made so as not to interfere with the vastus medialis oblique. Interference screw fixation was used on the femoral and tibial side. The size of the interference screw was determined by the amount of space created by the bone plug within the tunnel.<sup>19</sup> Once the screw was fixed, the

fixation strength was tested manually by the surgeon. The patella defect was grafted with autogenous tibial bone, and the patella tendon defect was closed. Patients' reconstructed knees were braced in a splint locked in extension.

### **Rehabilitation**

Continuous passive motion machines were used in the hospital the day after surgery. The patient also was instructed in home postoperative exercises. With the exception of early weightbearing status, the rehabilitation protocol was the same for both groups. For all patients, formal rehabilitation began 7 to 10 days after surgery. At 2 weeks after surgery, all patients began a program that emphasized physical modalities such as ice, electric stimulation, compression, and electromyography biofeedback.

### **Statistical Analysis**

The primary statistic used in this study was repeat measures analysis of variance (ANOVA) with treatment group (immediate weightbearing versus nonweightbearing) as the between subjects factor and time (preoperative, 2 weeks, followup) as the within subjects factor. Differences between specific points were analyzed by paired or independent t tests with the Bonferroni correction when a significant F ratio was found. Means are reported  $\pm$  standard error of the mean.

## **RESULTS**

The average age of the 24 male and 25 female patients was 30 years  $\pm$  1 year. There was no significant preoperative differences between the groups with regard to knee ROM, knee stability, Lysholm scores, or vastus medialis oblique electromyography activity. There was no difference between groups for age, height, or weight. Followup averaged 7.3 months, ranging between 6 and 14 months; 25 patients were in Group 1 (immediate weightbearing) and 20 patients were in Group 2 (nonweightbearing). Two patients from each group were lost to followup. One female patient in Group 1 tore her contralateral anterior cruciate ligament while skiing 9 months after surgery. Her 1-year followup data were not included for analysis because

measurements are based on side to side differences. However, her reconstructed knee remained clinically stable. In the immediate weightbearing group, there were 12 acute, five subacute, and five chronic tears. The nonweightbearing group had 18 acute, three subacute, and six chronic tears.

### Physical Examination Findings

The preoperative Lachman test results were graded as 1B in three nonweightbearing patients and two immediate weightbearing patients; 2B in 18 nonweightbearing patients and 24 immediate weightbearing patients; and 3B in three nonweightbearing patients and two immediate weightbearing patients). The preoperative pivot shift test results were graded as trace in one immediate weightbearing patient; +1 in two nonweightbearing patients and four immediate weightbearing patients; +2 in 14 nonweightbearing patients and 17 immediate weightbearing patients; and +3 in one nonweightbearing patient. The remaining patients were unable to be tested because of pain or apprehension. Medial collateral ligament laxity was present before surgery in nine of the nonweightbearing patients and was graded as +1 in three patients, +2 in two, and +3 in four; medial collateral ligament laxity was present in three of the immediate weightbearing patients and was graded +2. Before surgery, lateral collateral ligament laxity (+2) was present in only one patient in the immediate weightbearing group.

At followup, the Lachman test result was restored to a grade of A in all patients. The actual grades were: nonweightbearing group, 19 patients with 1A and two with 2A; and the immediate weightbearing group, 24 patients with 1A and three with 2A). After surgery, the pivot shift grades were improved to negative in 15 nonweightbearing patients and 19 immediate weightbearing patients; six patients in each group had a +1 grade. Two patients in the immediate weightbearing group had a grade of +2. The patient who had a +2 varus laxity before surgery was treated con-

servatively and had a grade of +1 at followup. Postoperative clinical examinations for pivot shift and Lachman also revealed no statistical differences between the two groups.

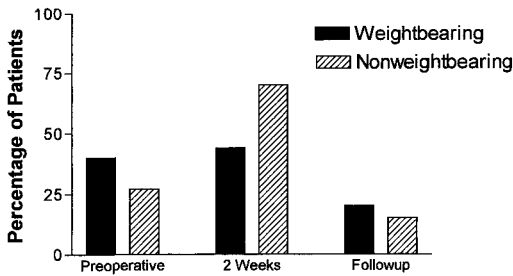
### Intraoperative Findings

The surgery revealed mild arthritis in both groups. Of the patients who had arthritis, six were in the acute group, one in the subacute group, and four in the chronic group. The nonweightbearing group had one patient with arthritis in the medial compartment, two with arthritis in the patellofemoral joint, and one with arthritis in the medial and lateral compartments. The immediate weightbearing group had three patients with arthritis in the medial compartment, one patient with arthritis in the lateral compartment, one patient with arthritis in the patellofemoral joint, one patient with combined medial and lateral compartment involvement, and one patient with arthritis in the lateral compartment and patellofemoral joint. There were two patients in the immediate weightbearing group who required chondroplasty.

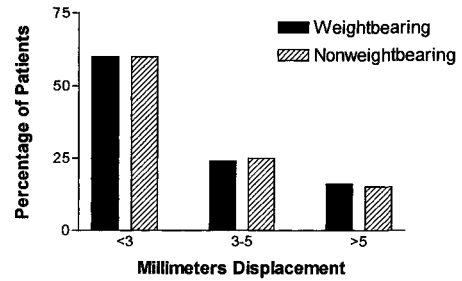
There was meniscus damage in patients in each group. The nonweightbearing patients had five medial tears, three lateral tears, and one patient with a tear in both menisci. These tears were in five acute and four chronic cases. Of these meniscal tears, four were left untouched, one was resected, one was rasped, and another was rasped, trephined, and repaired. The immediate weightbearing group had eight medial meniscus tears, one lateral tear, and five patients with both menisci torn. These tears were in eight acute and three chronic knees. Five of these tears were stable and were left alone, eight were resected, and the rest left alone.

### Range of Motion

Weightbearing did not have an effect on regaining ROM after surgery. Extension ROM was not significantly different at 2 weeks or at followup ( $p = 0.24$ ,  $p = 0.49$ ). Seventeen of the 22 nonweightbearing patients lacked



**Fig 1.** This histogram shows the percentage of patients who lacked knee extension ROM greater than 4° compared with the uninvolved knee. There were no statistical differences between the groups at any point in time.



**Fig 2.** This histogram shows the anterior tibial displacement differences of KT-1000 arthometer testing at followup. Weightbearing did not have an effect on knee joint stability.

greater than 5° extension at 2 weeks, compared with 10 of 27 immediate weightbearing patients ( $p < 0.01$ ) (Fig 1). Both groups reported similar extension losses of 5° or more at late followup: three of 20 (14%) patients in the nonweightbearing group and five of 25 (20%) in the immediate weightbearing group (Fig 1). There was no effect of the time from injury to surgery on regaining knee extension ROM ( $p = 0.93$ ). The return of flexion ROM difference was not significantly different between the groups ( $p = 0.76$ ). The average flexion loss at followup of 1 year was  $1.5^\circ \pm 1.0^\circ$  (range,  $-5^\circ$ – $10^\circ$ ) for the immediate weightbearing group and  $2.1^\circ \pm 1.0^\circ$  (range,  $-5^\circ$ – $10^\circ$ ) for the nonweightbearing group, which was not found to be significant ( $p = 0.61$ ).

### Knee Stability

Preoperative KT-1000 scores were  $5.6 \pm 0.5$  for the nonweightbearing group and  $6.2 \pm 0.5$  for the immediate weightbearing group. There was a significant effect of surgery on restoring knee stability ( $p = 0.01$ ), but there was no difference between the groups at followup ( $p = 0.70$ ). At followup, KT-1000 scores revealed the nonweightbearing group had an average maximum manual difference of  $2.4 \pm 0.70$  (range,  $-2.0$ – $9.0$ ). The immediate weightbearing group average KT-1000 arthrometer values were  $2.8 \pm 0.5$  mm (range,  $-3.5$ – $8.0$  mm) (Fig 2).

### Vastus Medialis Oblique Activity

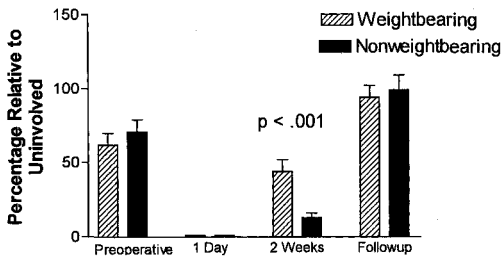
Before surgery both groups had similar vastus medialis oblique electromyography activity (nonweightbearing group,  $71\% \pm 7\%$ ; immediate weightbearing group,  $62\% \pm 7\%$ ), indicating that vastus medialis oblique activity was depressed before surgery. There was 0 activity for both groups 1 day after surgery in the 25 patients tested. At 2 weeks, the immediate weightbearing patients had significantly greater vastus medialis oblique electromyography activity (relative to uninvolved) ( $p = 0.002$ ). However, at followup both groups had restored their vastus medialis oblique electromyography to activity to near normal activity (Fig 3).

### Anterior Knee Pain

Seven of 20 (35%) nonweightbearing patients and two of 25 (8%) immediate weightbearing patients reported anterior knee pain at followup ( $p = 0.03$ ). No patient with anterior knee pain had a knee flexion contracture of greater than 5°. A strong trend toward a lower vastus medialis oblique electromyography was observed at 2 weeks in the patients who had anterior knee pain develop at 6 months ( $14\% \pm 7\%$  deficit versus  $40\% \pm 7\%$  deficit,  $p = 0.08$ ).

### Lysholm and Tegner Scores

Preoperative Lysholm scores were  $58 \pm 3$  for the immediate weightbearing group and  $63 \pm$



**Fig 3.** This histogram shows the amount of vastus medialis oblique electromyography muscle activity relative to the uninvolved knee. The groups had similar activity levels before surgery. One day after surgery neither group had vastus medialis oblique electromyography muscle activity. At 2 weeks, the weightbearing group had significantly more activity, but at 6 months both groups had returned to near normal activity.

5 for the nonweightbearing group. The mean postoperative Lysholm scores at followup were: immediate weightbearing group, 87 (range, 64–100); and nonweightbearing group, 84 (range, 60–100). Anterior cruciate ligament reconstruction significantly improved Lysholm scores ( $p = 0.03$ ). At followup, 12 (60%) patients of the nonweightbearing group and 17 (68%) of the immediate weightbearing group had good to excellent results, according to the Lysholm score (95–100, excellent; 85–94, good). The remaining patients in each group (six nonweightbearing, seven immediate weightbearing) had a fair result (65–84, fair), and two nonweightbearing patients and one immediate weightbearing patient reported a poor result ( $< 65$ , poor). There was a significant interaction term between the two groups such that the improvement in Lysholm scores was significantly better for the immediate weightbearing group ( $p = 0.03$ ). There was no significant difference between the groups in the ability to achieve their desired activity level. Each group fell short of the goal of level 7 (nonweightbearing,  $\pm 2$ ; immediate weightbearing,  $6 \pm 2$ ).

## DISCUSSION

Although studies of graft biology have suggested that ligamentization does not occur for 18 months,<sup>30</sup> surgeons continuously have pushed to minimize the postoperative recuperation after anterior cruciate ligament reconstruction.<sup>2,18,21,22</sup> Henning et al<sup>7</sup> showed that level walking produced 36% as much elongation as an 80-pound Lachman test. Based on this basic science knowledge, many physicians now allow full weightbearing immediately after surgery. However, there needs to be a delicate balance between activity detrimental to the reconstruction and that essential to promote more rapid recovery. Until now the outcome of immediate weightbearing after anterior cruciate ligament reconstruction had never been tested in a prospective randomized designed study.

The accelerated rehabilitation program after anterior cruciate ligament reconstruction is a result of the comparison of two groups of patients with different rehabilitation programs after anterior cruciate ligament reconstruction.<sup>21</sup> The accelerated program includes the leg immediately braced in full extension for walking without crutches as tolerated. It also allows the full return to sports in as little as 4 to 6 months. In their retrospective study, Shelbourne and Nitz<sup>21</sup> indicated that patients in their accelerated rehabilitation program group were able to achieve full knee extension earlier and had less of an extension deficit, actually achieving hyperextension. These prospective results show no difference in knee extension ROM at 2 weeks or at followup. Several factors may have influenced this finding. Because both groups of patients in the current study were braced in full extension, it may not be possible to show a difference in earlier return of knee extension ROM between the groups as a result of immediate weightbearing. In addition, all patients in this study waited 3 weeks from injury to minimize the risk of arthrofibrosis. It is recommended that patients rehabilitate their injured knee to de-

crease knee joint effusion and restore knee extension ROM before surgery to reduce the risk of arthrofibrosis.<sup>13,23</sup>

In their retrospective study, Shelbourne and Nitz<sup>21</sup> found no difference in knee stability at 89 N between their two treatment groups. The results of this prospective study indicate no effect of weightbearing on knee stability testing at followup using the maximum manual KT-1000 arthrometer test. These results are supported by the findings of Barber-Westin and Noyes,<sup>3</sup> who showed that early motion and weightbearing did not result in an increased incidence of abnormal knee laxity in the early phase of rehabilitation. These authors suggest that abnormal displacements typically occur later in the rehabilitation period.

Anterior knee pain continues to remain a complication of anterior cruciate ligament reconstruction. In 1991, O'Brien et al<sup>15</sup> attributed the high incidence of anterior knee pain to the 6 weeks of immobilization in a cylinder cast but did not specify whether there was a decrease in vastus medialis oblique activity. Sachs et al<sup>20</sup> revealed a relationship among patellofemoral pain, flexion contracture, and quadriceps weakness after anterior cruciate ligament reconstruction. The results of the current study did not show a relationship between knee flexion contracture and anterior knee pain at followup. A recent prospective randomized study by O'Neill<sup>16</sup> showed a low incidence of anterior knee pain in patients with various techniques of arthroscopic anterior cruciate ligament reconstruction. The author attributed the low incidence of anterior knee pain to the encouragement of full weightbearing and a full ROM on the morning after the surgery. Bach et al<sup>1</sup> reported an 18% incidence of mild patella pain in 62 arthroscopically assisted anterior cruciate ligament reconstructed knees but were unable to correlate this to lacking knee extension ROM. These patients were allowed toe touch weightbearing at 2 weeks and were advanced 15 pounds weekly until the discontinuation of crutches at 6

weeks. The group's findings were similar to the current results of an 18% knee flexion contracture of greater than 5° for both groups at 6 months and the lack of correlation to reports of anterior knee pain. Based on the results of the current study, it would appear flexion contracture alone does not result in anterior knee pain.

The presence of anterior knee pain may be attributed to decreased vastus medialis oblique activity and the inability to control the patella early during rehabilitation. Patients who were allowed to bear weight early had a pronounced and significant increase in early quadriceps vastus medialis oblique electromyography activity at 2 weeks and less anterior knee pain. The beneficial effects of early capture of the quadriceps include early patellar mobility and earlier compressive loads on the patella. This may contribute to increased patellar hyaline cartilage nutrition and preserved subchondral bone strength. It may be possible that this early period is vital in maintaining normal patellofemoral mechanics. In addition, a large knee joint effusion may cause abnormal mechanical tracking of the patella as a result of the fluid beneath the patella.

Quadriceps reflex inhibition has been well documented throughout the literature.<sup>4,5,8,9,24,25,27</sup> Whether the inhibition occurs as a result of capsular stretching, as Snyder-Mackler et al<sup>24</sup> have suggested, or is the result of increased intraarticular pressure, as shown by DeAndrade et al<sup>4</sup> and Spencer et al,<sup>25</sup> quadriceps shutdown is evident immediately after anterior cruciate ligament reconstruction, as the current results showed. Although, weightbearing does not affect the amount of effusion, it was able to override the vastus medialis oblique reflex inhibition to increase vastus medialis oblique muscle activity in the immediate weightbearing group.

The use of immediate weightbearing after anterior cruciate reconstruction results in a lower incidence of anterior knee pain. Immediate weightbearing helps to override the reflex inhibition of the quadriceps, as documented by electromyography at the 2-week followup.

There was no detrimental effect on knee stability or function when patients are instructed to immediately bear weight after anterior cruciate ligament reconstruction. Consequently, this prospective randomized trial indicates the superiority of early weightbearing after anterior cruciate ligament reconstruction.

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