



## Arthroscopic anterior cruciate ligament reconstruction using bone-patellar tendon-bone graft: a 14-year follow-up study

Kemik-patellar tendon-kemik greftiyle artroskopik ön çapraz bağ rekonstrüksiyonu:  
14 yıllık takip çalışması

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**Objectives:** We evaluated the long-term results of arthroscopic anterior cruciate ligament (ACL) reconstruction with autogenous bone-patellar tendon-bone graft in athletes.

**Patients and methods:** A total of 112 athletes (82 males, 30 females; mean age 27 years; range 20 to 35 years) underwent ACL reconstruction with central third of bone-patellar tendon-bone autograft. The mean time from injury to surgery was 18 months (range 2 days to 26 months). Thirty-eight patients had acute symptoms. Preoperatively, the Lachman and pivot shift tests were positive in all the patients. After a minimum of 14 years (mean 15.8 years), all the patients were assessed by subjective evaluations, and objectively with the KT-1000 arthrometer testing, radiographs as well as second-look arthroscopy in 39 patients.

**Results:** On subjective evaluations, the results were excellent in 62 (55.4%), good in 33 (29.5%), fair in 12 (10.7%), and poor in five patients (4.5%). No limitation of movement was seen in 95 patients (84.8%). The Lachman and pivot shift tests were negative in 74 (66.1%) and 99 (88.4%) patients, respectively. Radiographically, osteoarthritic changes were detected in 17 patients (15.2%), whose results were fair or poor, who had associated meniscal or osteochondral injuries prior to surgery, and who gave up preinjury sports activities. In KT-1000 arthrometer testing, side-to-side difference was less than 2 mm in 74 patients. At second-look arthroscopy, 30 patients had well-remodelled grafts; of these 11 patients had a positive Lachman test, and three patients had a positive pivot shift test. Spontaneous lysis of various degrees was detected in nine patients, of whom only two had a positive Lachman test.

**Conclusion:** Reconstruction of the ACL using a bone-patellar tendon-bone graft is recommended for acute or chronic ACL deficiency in athletes.

**Key words:** Anterior cruciate ligament/surgery; arthroscopy; bone-patellar tendon-bone graft; knee joint; tendons/transplantation.

**Amaç:** Bu çalışmada, sporcularda kemik-patellar tendon-kemik otogreftiyle artroskopik ön çapraz bağ (ÖÇB) rekonstrüksiyonunun uzun dönem sonuçları değerlendirildi.

**Hastalar ve yöntemler:** Toplam 112 sporcuya (82 erkek, 30 kadın; ort. yaş 27; dağılım 20-35) santral 1/3 kemik-patellar tendon-kemik otogreftiyle ÖÇB rekonstrüksiyonu uygulandı. Yaralanma ile cerrahi arasında geçen ortalama süre 18 ay (dağılım 2 gün-26 ay) idi. Otuz sekiz hastada semptomlar akut özellikteydi. Ameliyat öncesinde Lachman ve pivot şift testleri tüm hastalarda pozitif idi. En az 14 yıllık (ortalama 15.8 yıl) takipten sonra tüm hastalar subjektif ölçütlerle ve objektif olarak KT-1000 artrometre, radyografi, ve 39 hasta ayrıca ikinci artroskopiyle değerlendirildi.

**Bulgular:** Subjektif değerlendirmelerde sonuçlar 62 hastada (%55.4) mükemmel, 33 hastada (%29.5) iyi, 12 hastada (%10.7) orta, üç hastada (%4.5) kötü bulundu. Doksan beş hastada (%84.8) hareket kısıtlılığı hiç yoktu. Son kontrollerde Lachman testi 74 hastada (%66.1), pivot şift testi 99 hastada (%88.4) negatif bulundu. Radyografik değerlendirmede 17 hastada (%15.2) osteoartritik değişiklik saptandı. Bu hastalarda sonuç orta veya kötü idi; cerrahiden önce hepsinde meniskal veya osteokondral yaralanma vardı ve hepsi de yaralanma öncesindeki sportif etkinliklerine devam edememişti. KT-1000 artrometrede, 74 hastada iki taraf farkı 2 mm'den azdı. İkinci artroskopiye, greftlerin 30 hastada iyi remodele olduğu gözlemlendi; bu hastaların 11'inde Lachman testi, üçünde pivot şift testi pozitif idi. Dokuz hastada ise değişen derecelerde spontan lizis izlendi; bu hastaların sadece ikisinde Lachman testi pozitif bulundu.

**Sonuç:** Akut ya da kronik ÖÇB yetersizliği olan sporcularda kemik-patellar tendon-kemik otogreftiyle ÖÇB rekonstrüksiyonu önerilebilecek bir tedavi yöntemidir.

**Anahtar sözcükler:** Ön çapraz bağ/cerrahi; artroskopi; kemik-patellar tendon-kemik grefti; diz eklemi; tendon/transplantasyon.

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Anterior cruciate ligament (ACL) rupture is a common sports-related injury, which often markedly reduces athletic activity and the quality of life.<sup>[1]</sup> The ACL is the primary stabilizer of anterior translation of the tibia on femur and counteracts rotational and valgus stresses.<sup>[2]</sup>

In high-demand activities such as pivoting, cutting and side stepping during football, rugby and hockey, ACL-deficient knee leads to instability.<sup>[1]</sup> The resultant chronic instability and recurrent episodes of giving way may give rise to various intra-articular injuries including meniscal tears and osteochondral damage.<sup>[1,3,4]</sup> The incidence of erosion of the articular cartilage in patients with long-standing ACL deficiency may extend from 58 to 96 percent.<sup>[5]</sup> Following ACL reconstruction, these athletes resume their sports activities, resulting in delay in the onset of osteoarthritis.<sup>[1,6]</sup>

There are several techniques for ACL reconstruction including open surgical repair, open repair augmented with a synthetic ligament-augmentation device, open reconstruction with intra-articular graft, arthroscopic reconstruction with intra-articular graft, and extra-articular augmentation.<sup>[7-9]</sup> Reconstruction with bone-patellar tendon-bone (B-PT-B) graft is a well-accepted method of dealing with the ACL-deficient knee.<sup>[10,11]</sup> This procedure proved very effective in the short-term.<sup>[12-14]</sup> However, there is little information regarding the long-term outcome of ACL reconstruction with this method.<sup>[1]</sup>

We present a minimum of 14-year follow-up results of ACL reconstruction using central third of B-PT-B graft.

**TABLE I**

Distribution of patients according to engagement in sports

Sports	No. of patients	%
Soccer	61	54.5
Hockey	15	13.4
Gymnastics	11	9.8
Volleyball	7	6.3
Cricket	5	4.5
Tennis	5	4.5
Jogging	3	2.7
Swimming	2	1.8
Badminton	2	1.8
Bicycling	1	0.9

## PATIENTS AND METHODS

The study included 112 patients (82 males, 30 females; mean age 27 years; range 20 to 35 years) who underwent ACL reconstruction between 1989 and 1991 at Sehgal Nursing Home and Neurological Research Centre and Fortis Hospital, New Delhi. Only those who were engaged in active sports were enrolled (Table I). Involvement was on the right side in 61 patients, and on the left side in 51 patients. Those who had any other ligament injuries were excluded.

The most common mechanism of injury was internal rotation of the tibia on the femur and/or varus (n=36) followed by external rotation and/or valgus rotation (n=31) (Table II).

The mean length of time from injury to surgery was 18 months (range 2 days to 26 months). Thirty-eight reconstructions were performed in the acute stage. The main indication for surgery was instability in high-demand patients (n=103). In only nine cases, reconstruction was performed because of repeated meniscal injuries causing pain and swelling that were associated with ACL deficiency. Preoperatively, the Lachman<sup>[15]</sup> and pivot shift<sup>[16]</sup> tests were positive in all the patients. All were keen to return to their preinjury level of sports.

Arthroscopic findings are given in Table III.

The ACL was reconstructed using central third of the patellar tendon in all cases (Fig 1a).

All the patients were evaluated subjectively according to the satisfaction level and confidence in the knee to return to contact sports, and objectively with the KT-1000 arthrometer testing,<sup>[17]</sup> radiographs as well as second-look arthroscopy in 39 patients. Degenerative changes that occurred in the postoperative period were evaluated using the International Knee Documentation Committee radiographic grading system. The mean follow-up was 15.8 years (range 14.2 to 19.8 years).

**TABLE II**

Mechanisms of injury

Mechanism	No. of patients	%
Internal rotation of the tibia and varus	36	32.1
External rotation and/or valgus	31	27.7
Hyperextension	7	6.3
Other	5	4.5
Did not remember	33	29.5

**TABLE III**  
Arthroscopic findings

Type of injury	No. of patients	%
Anterior cruciate ligament rupture	112	100.0
Medial meniscal tear	79	70.5
Lateral meniscal tear	68	60.7
Osteochondral injuries	12	10.7
Articular cartilage damage	57	50.9

### Statistical analysis

Data were recorded on an Excel spreadsheet. All the entries were checked for any possible keyboard error. For data analysis, statistical software SPSS 10.0 was used. The chi-square test was used for comparison of two groups where necessary.

## RESULTS

### Patients' satisfaction and activity level

The patients were asked whether they were satisfied with the operation. In 62 patients (55.4%), the result was excellent with no pain, no swelling, no limitation of movement, and return to preinjury sports level. Thirty-three patients (29.5%) reported no limitation of movement, but occasional mild pain, swelling after moderate to strenuous activities, and return to sports at a lower level and were rated as good. Twelve patients (10.7%) had a fair outcome defined by giving up sports, the presence of moderate pain, swelling even after light activities, and terminal restriction of movements. The result was poor in five patients (4.5%) who gave up sports and had moderate pain, swelling when sedentary, persistent instability, and limitation of movements.

### Clinical examination

Ninety-five patients (84.8%) exhibited no limitation of movements, whereas five patients (4.5%)

and 12 patients (10.7%) had extension losses of 0-5 degrees and 5-10 degrees, respectively.

The Lachman test was negative in 74 patients (66.1%); a positive sign of grade 1 or 2 was elicited in 33 patients (29.5%) and five patients (4.5%), respectively.

The pivot shift sign was negative in 99 patients (88.4%) and positive in 13 patients (11.6%; 4 grade 1, 9 grade 2).

### Radiographic findings

On final examinations, only 17 patients had osteoarthritic changes, of which reconstruction had been performed at an acute stage in six patients, and at a chronic stage in 11 patients. All these patients had associated meniscal or osteochondral injuries prior to surgery (Table IV). These were the patients whose results were fair or poor with terminal restriction of movements.

There was no significant difference between acute and chronic cases with respect to the development of degenerative changes ( $p=0.97$ ), suggesting that time to surgery did not influence degenerative changes in the knee joint.

### KT-1000 arthrometer

During the test, maximum stress was applied manually keeping the knee in 30 degrees of flexion. The result of the reconstructed knee was compared with that of the normal knee in each patient. Pre- and postoperative side-to-side differences are given in Table V.

### Second-look arthroscopy

Thirty-nine arthroscopic re-evaluations were made in response to a subsequent episode of injury, thereby affording a chance to evaluate the ACL graft (Table VI; Fig. 1b, 2). Of these patients, 13 had a positive Lachman test (11 grade 1, 2 grade

**TABLE IV**

Distribution of patients according to the IKDC grading system and the length of time to surgery

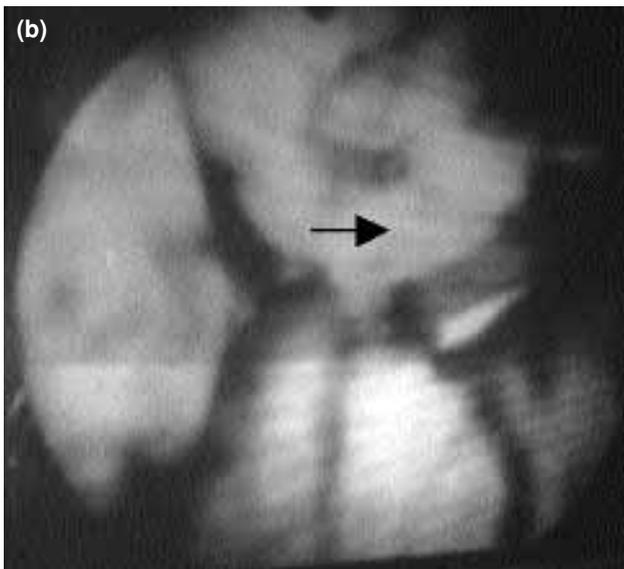
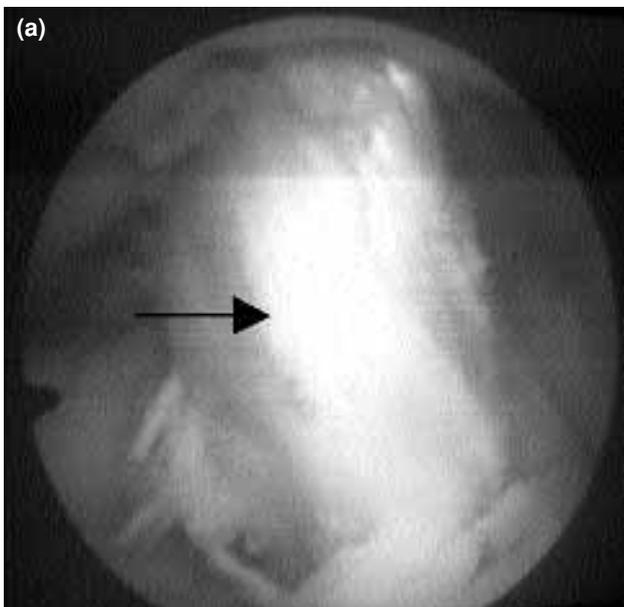
IKDC grade	Description	Acute reconstruction (<12 weeks, n=38)	Chronic reconstruction (>12 weeks, n=74)
A	Normal	32	63
B	Subchondral sclerosis, osteophytes, flattening of the femoral condyle	4	8
C	Increased sclerosis, large osteophytes, narrowing of the joint space	1	2
D	Changes in C plus less than 2 mm of joint space	1	1

IKDC: International Knee Documentation Committee

2), and three had a positive pivot shift test (1 grade 1, 2 grade 2).

**DISCUSSION**

Most patients in this study were satisfied with the outcome. Five patients who were unsatisfied often experienced moderate to severe pain and recurrent episodes of effusion on normal activities. Of the 112 cases, only 17 (15.2%) gave up their pre-injury sports, though 12 were still satisfied. These results are comparable to those of previous studies.<sup>[18-20]</sup> In contrast to a previous study,<sup>[11]</sup> there was no progressive deterioration in the satisfaction level as reported by Drogset et al.<sup>[9]</sup>



**Fig. 1.** (a) Intra-articular view of the ACL graft immediately after reconstruction. (b) Status of the graft after nine years.

**TABLE V**

Distribution of patients according to side-to-side differences in KT-1000 arthrometer testing

Side-to- side difference	Preoperative	Postoperative
<2 mm	3	74
2-5 mm	5	33
>5 mm	104	5

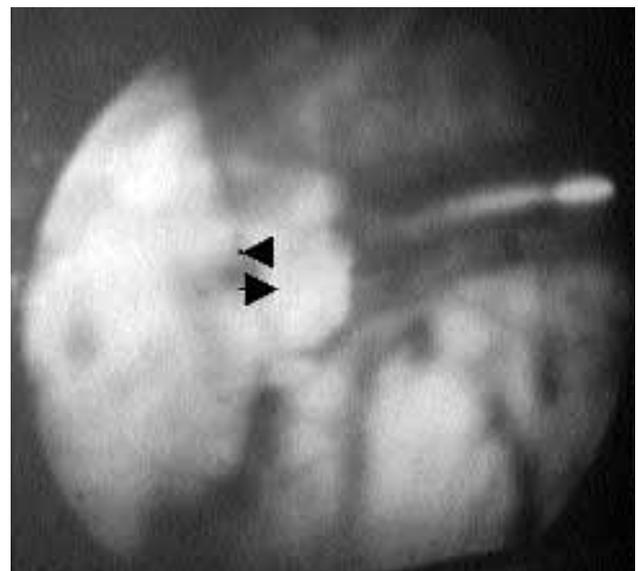
**TABLE VI**

Distribution of patients according to the status of ACL graft at second-look arthroscopy

Status of ACL graft	No. of patients
Well-remodelled ACL	30
Attenuated bands	6
Complete lysis	3

On final evaluations, only 17 patients had restriction of extension in terminal range. Of these, six patients underwent acute reconstruction, and 11 needed chronic reconstruction. There were no significant differences between acute and chronic cases in terms of limited range of motion ( $p>0.05$ ).

Radiographically, 17 knees (15.2%) showed osteoarthritic changes, being mild in 12, and moderate in five knees. The rate of osteoarthritic changes was surprisingly low in comparison to previous studies.<sup>[21,22]</sup> Clinically, these knees had restriction of movements. The development of



**Fig. 2.** Second-look arthroscopy in another case showing the ACL graft after 11 years.

degenerative changes was somewhat similar in both acute and chronic cases, indicating that time to surgery was not a predisposing factor for osteoarthritic changes, a finding that was also demonstrated by other studies.<sup>[1,23]</sup> Arthritic changes were seen in those knees that had associated meniscal and osteochondral injuries. To avoid degenerative changes, we now prefer to repair meniscal tears simultaneously where feasible.

Out of 39 knees which were arthroscopically evaluated after a subsequent episode of injury, nine exhibited spontaneous lysis of the graft, attenuated bands were noted in six, and in three knees only few strands of the graft persisted. The surprising point was that all these patients had no symptoms before the second operation and only two had a positive Lachman test (grade 1) and none had a positive pivot shift test, probably because they were balancing ligament deficiency with surrounding muscle power. On the other hand, of those who had a well-remodelled graft, nine had grade 1 and two had grade 2 Lachman test results, and one had grade 1 and two had grade 2 pivot shift sign. The long-term results of ACL reconstruction are variable in terms of arthroscopic findings and the presence of intact anatomical structure seems to have no obvious relationship with stability.

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#### REFERENCES

1. Jomha NM, Pinczewski LA, Clingeleffer A, Otto DD. Arthroscopic reconstruction of the anterior cruciate ligament with patellar-tendon autograft and interference screw fixation. The results at seven years. *J Bone Joint Surg [Br]* 1999;81:775-9.
2. Levy IM, Torzilli PA, Warren RF. The effect of medial meniscectomy on anterior-posterior motion of the knee. *J Bone Joint Surg [Am]* 1982;64:883-8.
3. Buss DD, Warren RF, Wickiewicz TL, Galinat BJ, Panariello R. Arthroscopically assisted reconstruction of the anterior cruciate ligament with use of autogenous patellar-ligament grafts. Results after twenty-four to forty-two months. *J Bone Joint Surg [Am]* 1993; 75:1346-55.
4. Arnold JA, Coker TP, Heaton LM, Park JP, Harris WD. Natural history of anterior cruciate tears. *Am J Sports Med* 1979;7:305-13.
5. Johnson RJ, Eriksson E, Haggmark T, Pope MH. Five-to ten-year follow-up evaluation after reconstruction of the anterior cruciate ligament. *Clin Orthop Relat Res* 1984;(183):122-40.
6. Lynch MA, Henning CE. Osteoarthritis in ACL deficient knee. In: Feagin JA, editor. *The crucial ligaments: diagnosis and treatment of ligamentous injuries about the knee*. New York: Churchill Livingstone; 1988. p. 385-91.
7. Jackson DW, Jennings LD. Arthroscopically assisted reconstruction of the anterior cruciate ligament using a patella tendon bone autograft. *Clin Sports Med* 1988; 7:785-800.
8. Amirault JD, Cameron JC, MacIntosh DL, Marks P. Chronic anterior cruciate ligament deficiency. Long-term results of MacIntosh's lateral substitution reconstruction. *J Bone Joint Surg [Br]* 1988;70:622-4.
9. Drogset JO, Grontvedt T, Robak OR, Molster A, Viset AT, Engebretsen L. A sixteen-year follow-up of three operative techniques for the treatment of acute ruptures of the anterior cruciate ligament. *J Bone Joint Surg [Am]* 2006;88:944-52.
10. Johnson RJ, Beynon BD, Nichols CE, Renstrom PA. The treatment of injuries of the anterior cruciate ligament. *J Bone Joint Surg [Am]* 1992;74:140-51.
11. Otero AL, Hutcheson L. A comparison of the doubled semitendinosus/gracilis and central third of the patellar tendon autografts in arthroscopic anterior cruciate ligament reconstruction. *Arthroscopy* 1993;9:143-8.
12. Marder RA, Raskind JR, Carroll M. Prospective evaluation of arthroscopically assisted anterior cruciate ligament reconstruction. Patellar tendon versus semitendinosus and gracilis tendons. *Am J Sports Med* 1991; 19:478-84.
13. Moyer RA, Betz RR, Iaquinto J, Marchetto P, Alburger PD, Clancy M. Arthroscopic anterior cruciate reconstruction using the semitendinosus and gracilis tendons: preliminary report. *Contemp Orthop* 1986;12:17-23.
14. Sgaglione NA, Schwartz RE. Arthroscopically assisted reconstruction of the anterior cruciate ligament: initial clinical experience and minimal 2-year follow-up comparing endoscopic transtibial and two-incision techniques. *Arthroscopy* 1997;13:156-65.
15. Gurtler RA, Stine R, Torg JS. Lachman test evaluated. Quantification of a clinical observation. *Clin Orthop Relat Res* 1987;(216):141-50.
16. Galway HR, MacIntosh DL. The lateral pivot shift: a symptom and sign of anterior cruciate ligament insufficiency. *Clin Orthop Relat Res* 1980;(147):45-50.
17. Daniel DM, Malcom LL, Losse G, Stone ML, Sachs R, Burks R. Instrumented measurement of anterior laxity of the knee. *J Bone Joint Surg [Am]* 1985;67:720-6.
18. O'Brien SJ, Warren RF, Pavlov H, Panariello R, Wickiewicz TL. Reconstruction of the chronically insufficient anterior cruciate ligament with the central third of the patellar ligament. *J Bone Joint Surg [Am]* 1991;73:278-86.
19. Clancy WG Jr, Nelson DA, Reider B, Narechania RG.

- Anterior cruciate ligament reconstruction using one-third of the patellar ligament, augmented by extra-articular tendon transfers. *J Bone Joint Surg [Am]* 1982; 64:352-9.
20. Sgaglione NA, Warren RF, Wickiewicz TL, Gold DA, Panariello RA. Primary repair with semitendinosus tendon augmentation of acute anterior cruciate ligament injuries. *Am J Sports Med* 1990;18:64-73.
  21. Myklebust G, Holm I, Maehlum S, Engebretsen L, Bahr R. Clinical, functional, and radiologic outcome in team handball players 6 to 11 years after anterior cruciate ligament injury: a follow-up study. *Am J Sports Med* 2003;31:981-9.
  22. Otto D, Pinczewski LA, Clingeleffer A, Odell R. Five-year results of single-incision arthroscopic anterior cruciate ligament reconstruction with patellar tendon autograft. *Am J Sports Med* 1998;26:181-8.
  23. Plancher KD, Steadman JR, Briggs KK, Hutton KS. Reconstruction of the anterior cruciate ligament in patients who are at least forty years old. A long-term follow-up and outcome study. *J Bone Joint Surg [Am]* 1998;80:184-97.