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The results of reconstruction of the ACL using the cross-pin femoral system and four-strand hamstring tendon autografts

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Objective: The aim of this study was to evaluate the results of ACL reconstruction using a cross-pin femoral fixation system and hamstring autografts.

Methods: The study included 49 men and one woman (mean age: 27.4 years; range: 15 to 44 years) with chronic ACL ruptures operatively treated between 2003 and 2006. Involvement was in the right knee in 27 patients, and the left knee in 23. There were no professional athletes included in the study. Patients with chondral lesions of the knee treated by microfracture or drilling or operated previously were excluded from the study. All patients had an ACL reconstruction with an autogenous four-strand hamstring graft. Thirty-five patients received treatment for other meniscal pathologies. All patients followed a similar accelerated rehabilitation program after surgery. Final evaluations were made using the Lysholm and International Knee Documentation Committee (IKDC) scoring systems and the Tegner activity rating system in the final follow-up.

Results: Mean follow-up time was 43.9 (range: 29-57) months. Lysholm scores were good or excellent for 47 patients. IKDC scores were either Grade A or B for 48 patients. The mean Tegner activity score was 5.9 (range: 4-9) in the preoperative and 5.4 (range: 2-9) in the late postoperative period.

Conclusion: Reconstruction of the ACL using four-strand hamstring tendons and cross-pin femoral fixation may be a safe and effective method, resulting in considerably high success rates.

Key words: Anterior cruciate ligament; arthroscopy; reconstructive surgery; cross-pin.

Anterior cruciate ligament (ACL) tears are among the most common knee injuries. The improvement in surgical techniques resulted in a wide range of graft options in the reconstruction of these injuries. Recently, bone-tendon-bone (BTB) and hamstring auto-grafts have become the most commonly used grafts.[1-4] Current research in ACL reconstruction focuses on more secure reconstruction methods that allow early rehabilitation protocols.[5,6] The rapid development and change, starting with use of interference screws for the femoral side, was followed by the introduction of EndoButton (Acufex, Smith & Nephew, Andover, MA, USA) and later the cross-pin. In light of these advances, anatomic ACL reconstruction is more frequently used.[7,8]

In this study, we aimed to evaluate the mid-term clinical outcomes of ACL reconstruction using a cross-pin femoral fixation system and four-strand hamstring autografts.

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Patients and methods

We prospectively evaluated the radiological and clinical outcomes of 50 patients (49 men and one woman; mean age: 27.4, range: 15-44 years) who underwent arthroscopic reconstruction upon diagnosis of ACL rupture in our clinic between September 2003 and May 2006. Patients were examined by the same two individuals with the anterior drawer, Lachman and pivot shift tests. Diagnosis was confirmed with MRI. Subjects with previous ACL reconstruction in the same knee, multi-direction instability, cartilage injury, or previous meniscal repair were not enrolled in the study. Lysholm, IKDC scoring and Tegner activity rating systems were used in the preoperative and final clinical evaluations.

Injuries were due to football in 18 cases, other sports in 18, military training in 10, skiing in 3 and non-vehicle traffic accident in one. For 10 patients with an acute ACL tear, a preoperative conservative rehabilitation protocol was administered for a mean of 3 (range: 2-6) months. In the overall series, the mean time lapse before operation was 20.5 (range: 2-96) months. There was an accompanying tear in the medial meniscus in 25 patients, the lateral meniscus in 9 and the bilateral menisci in one. These patients underwent partial meniscectomy during the ACL reconstruction. Cases with cartilage injury and without stable meniscus were not included in the study.

Mean operation time was 75 (range: 60-120) minutes. In all cases an autogenous four-strand hamstring graft and either the Transfix (Arthrex, Naples, FL, USA) or Slingshot (Mitek, Ethicon, Inc., NJ, USA) cross-pin system was used (Figs. 1 and 2). For tibial fixation, a metal or absorbable interference screw was used inside the tunnel and a notched washer screw or U-screw was used outside the tunnel. In five cases more than one attempt was necessary to pass the guide wire through the hook in the femoral tunnel. The guide wire broke off and was replaced with a new one in three cases.

Angle-adjustable long knee braces were used for the first three weeks postoperatively to ensure a controlled mobilization. Partial weight-bearing was allowed for the first three weeks for balance purposes only. Flexion was started at 80 degrees and increased by 10 degrees weekly, for 6 weeks. An unlimited range of knee motion was allowed at Week 6. At the end of the third month jogging was allowed and non-competitive sports at the sixth month. At Month 9 all activity restrictions were lifted.

At the last follow-up, knee proprioception was measured against the healthy side.

In addition, circumference measurements made in 15 cm proximal to superior pole of the patella were also evaluated.

Results

Mean follow-up time was 43.9 (range: 29-59) months. Final evaluation was performed in the final control visit, at least 29 months after the operation.

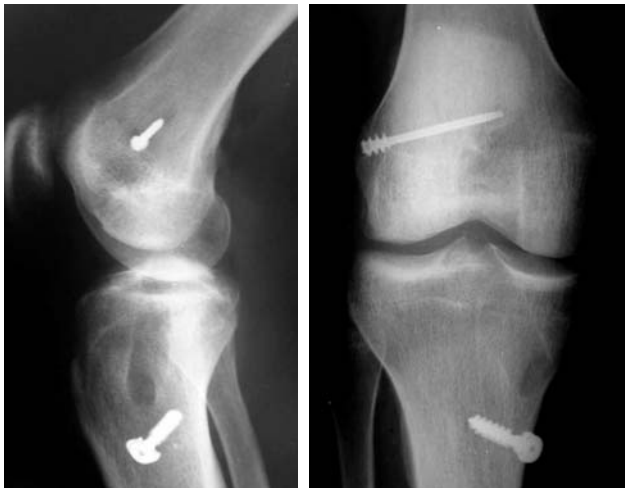

Fig. 1. X-ray taken postoperative Month 6. Slingshot system was employed for femoral fixation.

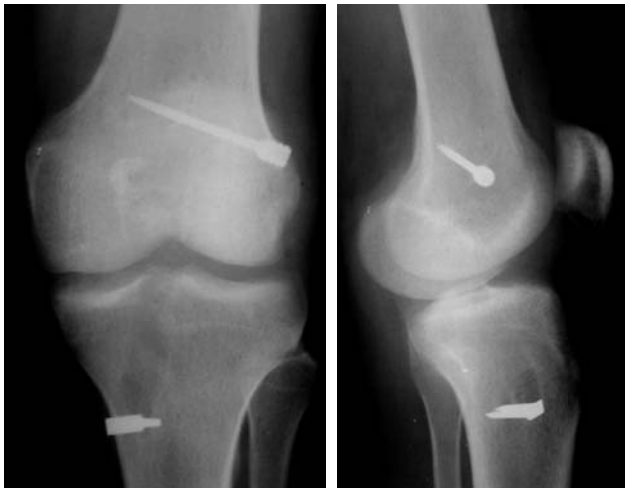

Fig. 2. X-ray taken postoperative Month 32. Transfix system was employed for femoral fixation.

Preoperative Lysholm scores rose from a mean of 55 (range: 37-85) to a mean of 93.4 (range: 70-100) in the final control. According to the Lysholm scoring, 47 patients had perfect or good results (Table 1). According to the IKDC knee ligaments standard evaluation system, it was found that 5 cases (10%) were in Group B, 32 cases (64%) were in Group C and 13 cases (26%) were in Group D preoperatively. In the postoperative examination, 37 cases (74%) were included in Group A, 11 (22%) in Group B, and 2 (4%) in Group C (Table 2). While the mean Tegner activity score was 5.9 (range: 4-9) preoperatively, it was found to be 5.4 (range: 2-9) in the postoperative late follow-up examinations (Table 3).

The error margin in the measurement of proprioception was below 5 degrees in 27 patients, 5 degrees in 6, 10 degrees in 13 and 15 degrees in 4. The corresponding margin in healthy knees was at or below 5 degrees in all but one patient with a torn ACL in the non-operated knee. While the error margin was 5 degrees in his operated knee, it was measured as 10 degrees in the knee with ligament tear.

In measurements made 15 cm proximal to the superior pole of the patella, the decrease in the circumference was 1 cm in 14 patients, 2 cm in 10 and 3 cm in 2 preoperatively. In the postoperative final control, the circumference decrease was 3 cm in 4 patients, 2 cm in 8 and 1 cm in 5. Quadriceps exercises were re-started in patients with 3 cm decrease in circumference.

In one case, a patient's graft fell on the floor during surgery preparation. The procedure continued after the graft was immersed for 30 minutes in a solution of antibiotics and antiseptic agents. This patient, who experienced no postoperative infection, had a follow-up period of approximately 52 months, a Lysholm score of 98, Tegner activity score of 6, a IKDC score of normal.

When one of our patients complained of knee pain in postoperative month 50, we referred to a nearby orthopaedic center where he had arthroscopic examination. There was a peripheral tear in the medial meniscus; the graft had completed its integration, and there was no laxity. One month later we were informed that the pain was relieved and he was able to return to work.

Three of our patients were re-hospitalized with a suspected infection and antibiotherapy was administered. One patient received hyperbaric oxygen therapy in addition to antibiotherapy. The absorbable tibial fixation materials of these patients were removed at the end of the second year. No recurrence was seen. In one of these patients, there was no other finding suggesting infection and the inflammation was attributed to an allergic reaction.

Table 1. Preoperative and postoperative Lysholm scoring results.

Lysholm score	Pre-op	Post-op
30-55	29	-
56-80	16	3
81-100	5	47

Table 2. Preoperative and postoperative IKDC scoring results.

IKDC score	Pre-op	Post-op
A	-	37 (74%)
B	5 (10%)	11 (22%)
C	32 (64%)	2 (4%)
D	13 (26%)	-

Table 3. Preoperative and postoperative Tegner scoring results.

Tegner score	Pre-op	Post-op
1	-	-
2	-	1
3	-	2
4	4	5
5	14	20
6	18	15
7	9	5
8	4	1
9	1	1
10	-	-

Table 4. Preoperative and postoperative complications.

Peroperative complication	
Graft fall on the floor	1 patient
Tibial interference screw into the joint	1 patient
Rupture of the carrying wire	3 patients
Peroperative complication	
Hypoesthesia of graft harvesting area	3 patients
Superficial infection	3 patients
Allergic reaction	1 patient

The tibial fixation screw was removed in a patient when a joint penetration was suspected on the X-rays. In the postoperative 47th month the Lysholm score was 78 and IKDC score was C. The Tegner score still remains 2 (Table 4).

Discussion

Today, different grafts and fixation methods are used for ACL reconstruction, BTB and hamstring autografts being the most common. Four-strand hamstring grafts are not recommended in overweight patients (over ~100 kg), sprinters, subjects with medial laxity or with a pivot shift test result of 4(+).[9,10] Graft selection should be at the discretion of the surgeon in cases with these relative contraindications. In our study, four-strand hamstring grafts were not used in such patients.

Different methods are currently used in fixation with hamstring grafts. The most common include screws, EndoButtons and cross-pins. In a study conducted on graft fixation materials, Brand et al. stated that while cross-pins were not weaker than EndoButtons or other fixation methods in terms of force and loading, disadvantages included the need for an additional incision and the occurrence of dilatation.[11] Cross-pins need an extra incision, around 1.5-2 cm from the lateral aspect, however, we do not consider this a significant disadvantage. This incision did not present any complications in our series. In a study conducted on porcine, Becker et al. examined the rigidity and tensile strength of fixations made with patellar and four-strand hamstring tendons.[12] In this study, hamstring tendons were fixed using cross-pins or absorbable screws, while patellar tendons were fixed using titanium interference screws. In tests conducted under laboratory conditions, it was found that the cross-pin was superior to both methods in terms of both rigidity and tensile strength.

In an experimental study, Shen et al. compared EndoButtons and cross-pins and determined that one system was not superior to the other in general, but the pin was more durable in cyclic loadings and it may better allow early rehabilitation.[13]

In a similar study, Milano et al. reported that in ACL reconstruction, femoral side corticocancellous screw fixations (cross-pin) are the most durable and safe methods in terms of elongation, fixation force and rigidity.[14]

Clark et al. investigated the use of cross-pin on the femoral side both in an animal model and in a clinical trial.[15] At the end of the 30-month follow-up period, it was reported that the mean Lysholm score of their 22 patients was 93 (range: 83-100) and the mean Tegner score was 6 (range: 3-9). According to the IKDC scoring system, three were normal, 15 were borderline normal, three were abnormal and one was seriously abnormal. When we compared our results with those of this study, we observed that the mean Lysholm scores were identical and the Tegner scores were similar. Our results were better in terms of the IKDC scoring system. Clark et al. stated that the cross-pin is the best fixation method because of its ability to facilitate adequate reconstruction, a stronger femoral fixation and arthroscopic reconstruction with a smaller incision. In the same study, revision was required in two patients due to nail migration and two other patients had their nails removed due to iliotibial band irritation two years after the operation. In our cases, nail migration or irritation was not observed.

Ma et al. and Mahiroğulları et al. reported that, better bone and tendon union was achieved with femoral fixation from the distant end of the tunnel using a cross-pin and hamstring grafts than intra-tunnel screw fixation.[16,17] In cases with screw fixation, the screw is interposed between the bone and tendon. We believe one of the most important issues requiring consideration in fixation using the cross-pin method is that the diameter of the tendon and the tunnel be the same so that the tendon firmly fits into the tunnel.[18] Thus, less synovial fluid will flow into the tunnel and the possibility of dilatation in the tunnel will be reduced. No significant difference was found between hamstring graft fixations made proximally and distally in the femoral tunnel.[16-18] Particularly, an examination was also made for tunnel dilatation, but it was observed that the tunnel could also dilate in fixations with a screw at the tunnel opening. Although the authors did not state a definitive cause for the tunnel dilatation, they suggested that it might be related to micro-movement, the synovial fluid or challenges in the surgical technique.

Hame et al. investigated the efficiency of femoral notchplasty and stated that femoral notchplasty was

required for proper tunnel placement.[19] Harner et al. also emphasized proper tunnel placement and the necessity of femoral notchplasty to prevent the graft's impingement.[20] Taşer recommended performing notchplasty until the posterior border of the femur and also debriding the top of the notch in case of graft impingement.[21] In our cases, we routinely performed notchplasty using a shaver and/or curette. Osseous dilatation was performed in necessary cases. In cases with a narrow femoral notch, removal of the notch will be necessary to prevent graft impingement. As stated by Hame et al.,[19] adequate, but not exaggerated, femoral notchplasty is important to prevent possible early laxity.[19]

Klein et al. examined the width of the femoral tunnel in 27 cases, using femoral cross-pin fixation.[22] At month 18, the mean Lysholm score was 92.6. According to the IKDC scoring system, 11 patients were in Group A, 13 in Group B, and two in Group C. Clinical outcomes of this study are highly similar to ours. In the same study, tunnel dilatation was found in all cases; however, it was stated that these were not related with clinical outcomes nor caused by the "Bungee" cord or windshield wiper effect. The authors suggested that dilatation around the cross-pin may be the result of the pressure made by the graft against the surrounding walls. In our study, tunnel dilatation was not examined, but findings suggestive of tunnel dilatation of various degrees were observed in anteroposterior and lateral radiographs taken at one meter distance, on average in Month 24 (Figs. 1 and 2).

In a large series reporting mid- and long-term outcomes, Aşık et al. stated that cross-pin was successful and safe, with low morbidity rate. They emphasized that proper graft preparation, proper tunnel opening, femoral notchplasty, fixation methods and rehabilitation programs are as important as the selection of the graft and fixation material.[23] We share these opinions.

Authors such as Beynnon and Howell do not have their patients use a brace following ACL reconstruction.[24,25] We used angle-adjustable hinged knee braces in the postoperative period. Those not only ensure controlled movement, but also protect the graft by reducing the load on the graft until adequate quadriceps strength is achieved.[26] The principal aim is to obtain full quadriceps strength and good range of motion by the 3rd or 4th week. We continued the rehabilitation with straight leg raising exercises and kept the brace during 3 to 6 weeks until a motion in range of 0-120° was obtained. After the removal of the drain, we mobilized our patients and allowed weight bearing as much as tolerated. While early full weight bearing may lead to hemarthrosis which can impair rehabilitation, it should not be delayed more than 3 weeks.[26,27] This rehabilitation enabled all patients to return to contact sports within 6 months.

Proprioception makes contribution to motor planning and muscle reflex to ensure muscle-nerve control and, thus, provides dynamic joint stability.[28-30] Proprioceptive loss following ACL repair may impair knee functions.[31] Although a consensus exists on the importance of proprioceptive sense training, there is no consensus on the most valid method of assessment.[30,32,33] In recent years, there have been studies assessing proprioception using different methods.[34-36] We applied a practical test, similar to that in Erden's study in the final follow-up of our patients.[37] We would like to emphasize that proprioception should be considered in future studies.

Examination by different individuals with different expertise may influence clinical scores. Interobserver variations may occur, particularly in the Lachman and anterior drawer tests. To minimize the error margin we were careful to ensure that all examinations were performed by the same two examiners. One examiner had a moderate level of experience, while the other was highly experienced and the scores were independently given. No significant difference between the two score sets could be found.

The use of implants from two distinct companies was a limitation of our study.

Preliminary outcomes of this study have been published previously.[38] We observed that the results were highly satisfactory. The lack of substantial change in the Tegner activity score may be due to the patients' self-limitation of physical activity in order to protect the new ligaments.

In conclusion, our mid-term results showed that four-strand hamstring tendon grafts fixed with a cross-pin at the femoral side may be a safe and effective method for ACL reconstruction.

Conflicts of Interest: No conflicts declared.

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