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Early results of reconstruction of chronic anterior cruciate ligament ruptures using four-strand hamstring tendon autografts

Kronik ön çapraz bağ yırtığının dörtlü hamstring otogrefti ile rekonstrüksiyonunun erken dönem sonuçları

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Amaç: Bu çalışmada, dört katlı otogreft hamstring tendonu ve proksimal tespit için tekli çapraz çivi sistemi ile tedavi edilen kronik ön çapraz bağ (ÖÇB) yırtıklarının erken dönem sonuçları incelendi.

Çalışma planı: Çalışmaya kronik ÖÇB yırtığı olan 62 erkek hasta (ort. yaş 24; dağılım 21-44) alındı. Otuz iki hastada sağ dizde, 30 hastada sol dizde lezyon vardı. Tüm hastalar artroskopik olarak dört katlı otogreft hamstring tendonu ve proksimal tespit için tekli çapraz pin sistemi (Transfix, Arthrex ve Sling Shot, Mitek) ve tibial tarafta interferans vidası ile tedavi edildi. Kırk bir hastada diğer menisküs patolojilerine müdahale edildi. Tüm olgular ameliyat sonrası 18. ayda, Lysholm skorlaması, IKDC (International Knee Documentation Committee) skorlaması, Telos stres cihazı ölçümleri, Tegner aktivite skorlaması ve radyografilerle değerlendirildi.

Sonuçlar: Ameliyat sonrasında Lysholm skoru 61 hastada iyi (n=23) veya mükemmel (n=38), bir hastada kötü bulundu. Ortalama Lysholm skoru 93.5 idi. IKDC skorlamasına göre 61 hasta A (n=35) veya B (n=26) grubunda, bir hasta D grubunda yer aldı. Telos stres cihazı ile ameliyat öncesi (ort. 14.5 mm) ve ameliyat sonrası (ort. 2.6 mm) ölçülen laksite değerleri arasında anlamlı fark bulundu ($p<0.001$). Hiçbir hastada greftte yırtılma saptanmadı. Ameliyat sonrası altıncı ayda grade 3 instabilite saptanan bir hastada second-look artroskopide bağın gevşek olduğu görülerek revizyon yapıldı.

Çıkarımlar: Dörtlü hamstring tendonu ve proksimalde çapraz çivi sistemi ile yapılan ÖÇB rekonstrüksiyonunda, uygun olgularda oldukça yüksek bir başarı oranı sağlanmaktadır.

Anahtar sözcükler: Ön çapraz bağ/cerrahi; artroskopi; kemik çivisi; femur/cerrahi; diz eklemi/cerrahi; patella/cerrahi; rekonstrüktif cerrahi prosedür/enstrümantasyon; tendon/transplantasyon.

Objectives: We evaluated the short-term results of reconstruction of anterior cruciate ligament (ACL) ruptures using a four-strand hamstring autograft and cross pin femoral fixation.

Methods: The study included 62 male patients (mean age 24 years; range 21 to 44 years) with chronic ACL ruptures. Involvement was in the right knee in 32 patients, and in the left knee in 30 patients. All the patients were treated with a four-strand hamstring autograft, cross pin femoral fixation (Transfix, Arthrex and Sling Shot, Mitek), and an interference screw on the tibial side. Forty-one patients received treatment for other meniscal pathologies. Final evaluations were made at the end of postoperative 18 months using the Lysholm and IKDC (International Knee Documentation Committee) scoring systems, Telos stress testing, Tegner activity rating, and radiographs.

Results: The Lysholm scores were good (n=23) or excellent (n=38) in 61 patients, and poor in one patient, the mean Lysholm score being 93.5. The IKDC scores were grade A (n=35) or B (n=26) in 61 patients, and grade D in one patient. Telos stress testing showed a significant difference between preoperative (mean 14.5 mm) and postoperative (mean 2.6 mm) laxity measurements ($p<0.001$). None of the patients had a graft rupture. One patient who developed grade III instability after postoperative six months underwent second-look arthroscopy followed by revision surgery.

Conclusion: Reconstruction of the ACL using four-strand hamstring tendons and cross pin femoral fixation results in considerably high success rates in selected patients.

Key words: Anterior cruciate ligament/surgery; arthroscopy; bone nails; femur/surgery; knee joint/surgery; patella/surgery; reconstructive surgical procedures/instrumentation; tendons/transplantation.

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Anterior cruciate ligament (ACL) rupture is one of the major knee injuries throughout the world. ACL reconstruction is commonly performed in Turkey as well. Chronic ACL reconstruction has become increasingly popular particularly in the last three decades and several methods of reconstruction have been proposed. Number of patients undergoing ACL reconstruction has risen and more favorable results have been obtained with the advances in arthroscopic surgery and developments in ACL reconstruction equipment. A number of graft types have been developed in line with the developments in surgical equipment. BTB (bone-tendon-bone) and hamstring autografts are the most commonly used grafts of choice today. Post-operative rehabilitation protocols have also been developed significantly and accelerated early rehabilitation has become more popular. As better and firmer fixation was required to provide for early rehabilitation, better graft fixation methods have been developed as well. Rapid advances and changes starting with the use of interference screws were followed by EndoButton and cross pin systems. [1,2,3,4,5,6,7,8]

The purpose of this present study was to investigate the clinical results of single cross pin systems (Transfix [Arthrex], Slingshot [Mitek]) used in the femoral fixation of a four-strand hamstring autograft.

Patients and methods

A total of 62 patients diagnosed with chronic ACL rupture between 2000 and 2003 were administered with arthroscopic four-strand hamstring autograft and single metal cross pin system of 50 mm length for the proximal fixation (28 patients with transfix and 34 patients with slingshot cross pin) and interference screw on the tibial side. The results of these operations were investigated in this prospective non-randomized clinical study.

All patients were male with a mean age of 24 years (range: 21 – 44 years) at the time of surgery. While 32 patients had right knee lesions, the remaining 30 patients had lesions in the left knee. Of the patients, 18 had sustained ACL rupture while engaged in a recreational sports activity, whereas 32 had done so during military training and the remaining 12, during military operations. None of the patients had been engaged in a sports activity professionally. Mean elapsed time from trauma to surgery was 12 months (range: 3 - 36 months).

Patients administered with subchondral drilling or with microfractures due to severe cartilage lesions were excluded. Of the patients, 41 underwent additional meniscal surgery as deemed necessary during the operation. Of these, 13 patients were observed with tears in the medial meniscus while 17 patients had meniscal tears in the lateral meniscus. The remaining 11 patients had tears in both menisci. Of these patients with meniscal tears, 32 underwent partial meniscectomy and 9 had meniscal repair by using the “all-inside” (rapidlock - mitek) technique.

Diagnosis was based primarily on anamnesis and physical examination. The patients were administered with anterior drawer, Lachman and pivot shift tests. Diagnosis was confirmed by using MRI and Telos stress device. A noteworthy characteristic reported in all their anamneses was the fact that they had heard or felt a popping sound, a classical ACL rupture symptom, followed by rapid swelling in the knee, which incapacitated them, resulting in immobility. Of the 62 patients, 18 had presented at our clinic with acute injury and were administered with 3 months of conservative therapy to relieve symptoms and provide ROM again. Reconstruction was planned for a later date.

Surgical approach

All the patients were operated in a supine position under spinal or general anesthesia by using tourniquet. Firstly, diagnostic arthroscopy was performed and ACL rupture was confirmed visually. Four-strand semitendinosus and gracilis tendon grafts were prepared. When arthroscopy was re-initiated, meniscal pathologies were operated at first. Adequate amount of notchplasty was performed for all the patients. Tibial and femoral tunnels were prepared by using guides to accommodate the graft. The graft was hanged over the cross pin on the femoral side by utilizing the guides and wires for the systems (Figure 1). Holding wire and holding hook did not meet and missed the target in the femoral tunnel during the operation of the 5 patients out of the 62 patients. A second or third attempt was necessary for these patients. Holding wire broke in three of the patients and had to be replaced. While placing a fixation screw, the holding wire was moved in small steps from lateral to

medial to avoid jamming. The patients were administered with titanium interference screws developed for soft tissue. The screws were of the correct sizes according to tibial tunnel diameter and length (8x25, 8x30, 9x25, 9x30mm) for each of the patients. Particularly for the patients whose graft was not completely in the tunnel, 12 patients were administered with additional fixation with titanium cancellous screws with spiked washers and 16 patients with titanium staple. The mean time of surgery in our series was 75 minutes (range: 60 – 120 minutes).

Post-Operative Period

All patients used long adjustable knee braces for three months following surgery to provide more controlled stepping. For the first three weeks only static stepping for balance was allowed. In order to provide protection against hyperextension while stepping, brace angle were started with –10º extension and +80º flexion, increasing flexion by 10º weekly. Extension was left free when not stepped on. During the fifth week, flexion was limited to +110° but limits were removed for extension. Full range of motion was allowed by the sixth week. Exercises were performed during this process. Jogging was allowed after the third month and they were allowed to participate in non-competitive sports after the sixth month. The patients were given full freedom in their activities after the ninth month .[9,10]

Evaluation

Functional and clinical assessment of the patients was made in the 18th post-operative month. Lysholm scoring, IKDC (International Knee Documentation Committee) scoring, Telos stress device measurements, thigh atrophy measurement performed 15 cm proximal to patella's proximal end, and Tegner activity scoring were taken into consideration in the clinical evaluation. A simultaneous radiological assessment was carried out as well and the patients were checked for arthritic alterations and loss of fixation.[9,11,12]

Results

Functional and clinical assessments of the 62 patients were based on the clinical findings in the 18th post-operative month.

Of the 62 patients, 61 were categorized as good or excellent according to the Lysholm scores, with a mean Lysholm score of 93,5. One patient was classified as poor. While 61 patients were established in A and B groups according to IKDC scoring, one patient was observed in group D (Table 1). The patient with a poor outcome was the same patient for both classifications. The patient had grade III instability at 6 months after surgery. The patient underwent "second look" arthroscopy. The ligament was observed to be intact but it was not tight. The patient was subjected to a rehabilitation program until the 12th post-operative month. As there was only minimal improvement, revision surgery was performed.

None of the patients was observed with graft rupture. Lachman test results were 1 + in 14 patients.

While 38 of the 61 patients were categorized as

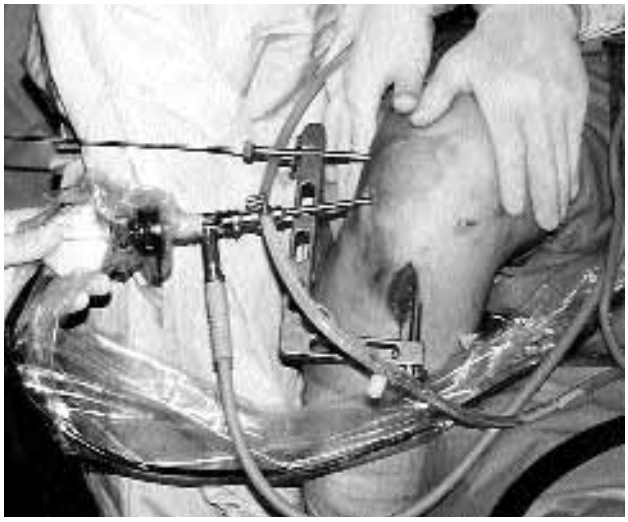

Figure 1. Use of cross pin system guide

Figure 2. Measurement by using Telos stress device

excellent, the remaining 23 patients were classified as good. More pain, thigh atrophy and minimal instability were the reasons for lower scores in the patients who were classified as good.

IKDC scoring resulted in 35 patients being categorized in group A and 26 patients being categorized as group B. The 26 patients in group B were those who had Lachman 1+ instability and had less than 5∞ loss of extension with 10∞ loss of flexion. The loss of flexion was more profound.

While the 32 patients who had undergone partial meniscectomy had a mean Lysholm score of 93.3, the mean Lysholm score for the group of patients who had sutures was 94.4. Of the 9 patients who had sutures, 6 (54%) were classified into group A according to IKDC scoring and three were in group B. Of the patients who had meniscectomy, 18 patients were in group A (57.6%) and 14 patients were in group B.

In the measurements taken from 15 cm proximal to upper pole of the patella, 12 patients were observed with 2 cm and 5 patients were observed with 3 cm atrophy.

None of the patients had significant hamstring or anterior knee pain while squatting down.

Lateral graphs for both knees were taken by applying 15 kg force during measurements carried out by using Telos stress device (Figure 2). Measurements were between back of femoral condyle and tibial plateau posterior border. Measurements of 10 mm and over indicated ACL pathologies. The difference between the left and right knees was established. A measurement of over 10 mm was observed only in one of the patients. Comparative results revealed differences of 3-5 mm in 26 patients and differences of 1-2 mm in 35 patients. These results were consistent with IKDC ligament examination. The difference between pre-operative (mean 14.5mm) and post-operative (mean 2.6mm) laxity measurements carried out on a Telos stress device was statistically significant (Wilcoxon test, $p < 0.001$).

Tegner activity scores demonstrated that 46 patients had moved up to “level 6” or “level 7” from “level 4”. The rest of the patients remained stable at their levels which were 4 or 5. Running and playing

Figure 3.(a) Anterior posterior graph at the 18th postoperative month,**(b)** Lateral graph at the 18th postoperative month

football were the most significant factors in Tegner activity scores. While the mean Tegner activity score before the operation was 4 (range: 3-4), post-operative mean score was observed to be 6 (range: 4-7).

At the end of the follow-up period radiological assessment did not reveal new osteoarthritic alterations in any of the patients. Moreover, osteoarthritis observed before and during the operation in some of the patients had not progressed postoperatively. None of the patients were established with inadequate femoral and tibial fixation as a result of radiological investigations (Figure 3-4).

None of the patients demonstrated complications such as infection, deep vein thrombosis or reflex sympathetic dystrophy.

Discussion

ACL rupture is one of the most common knee pathologies. ACL reconstruction is of major importance as it maintains knee stability and prevents osteoarthritic alterations which can develop rapidly. Various grafts and approaches are being utilized for ACL reconstruction in modern surgery. However, BTB and Hamstring autografts are among the most popular ones. Although BTB graft has been described as the golden standard, four-strand hamstring tendon autograft has also been utilized extensively. However, four-strand hamstring tendon autograft is not recommended for patients with higher body weight (above 90 kg), those who are short-distance runners, those with medial laxicity and those with a pivot shift test result of 4 (+). Surgeons are required to make the decision regarding the approach to be followed for patients with the above mentioned contra-indications. The patients with the above mentioned contra-indications have not undergone reconstruction by utilizing four-strand hamstring graft in our clinic.[1,13,14]

The methods for fixing hamstring grafts vary, as well. The most common ones are absorbable screws, EndoButton and cross pin systems.

In a study carried out by Brand et al. on graft fixation materials, which was published in the year 2000, it was reported that cross pinning system was not inferior to EndoButton and other fixation methods in terms of strength and load bearing. However, it was stated that it presented certain disadvantages as it required an extra incision and may lead to tunnel widening due to its positioning deep inside the tunnel. [7]

Rigidity and tension strength of quadruple tendon and patellar tendon femoral fixation techniques were investigated in a porcine study carried out by Becker et al. They fixed hamstrings by using transfix cross pin or absorbable screw, while patellar tendons were fixed with titanium interference screws before subjecting them to tests under laboratory conditions. It was reported that transfix was superior to the other two methods in terms of both rigidity and tension strength. [15]

Clark et al. published the results of both their study on animal model and their clinical study in their article on using femoral cross pins. It was reported that the mean Lysholm and Tegner scores for the 22 patients after a 30-month follow-up period were 93 (range: 83-100) and 6 (range: 3-9) respectively. IKDC scoring demonstrated that 3 patients were normal, 15 patients were close to normal, 3 patients were abnormal and 1 patient was severely abnormal. When their results were compared with our study, it was noted that the mean Lysholm scores were the same. Tegner scores were observed to be similar as well. According to IKDC scoring system, our results appeared to be better. However, given the shorter follow-up period of 18 months in our study, certain changes might be expected over time. Clark et al. stated that it cross pin femoral fixation was the method of choice when compared with the other femoral fixation techniques as it provided adequate femoral fixation, it was applicable through arthroscopy with a limited amount of incision and it allowed sufficient reconstruction. It was reported that two patients had undergone revision surgery due to pin migration in that same study. Similarly, the pins of two patients of the same cohort were removed two years after the operation due to iliotibial band irritation. Our patients were not observed with pin migration or irritation.[16]

As Ma et al. stated in their study, distant femoral fixation methods of hamstring tendons such as cross pin technique provided better bone tendon healing than methods using inside-tunnel screws. At least, tendon is in complete contact with the bone and

healing surface is increased. There is a screw between the bone and tendon when a screw is used. A point of critical importance in cross pin method in our opinion is making certain that the tendon diameter and tunnel diameter are exactly the same and that the tendon barely fits into the tunnel, as this will allow only a limited amount of synovial fluid into the tunnel and potential tunnel widening will be kept at a minimum. Tibial side is generally fixed by utilizing interference screws in patients undergoing reconstruction by using the cross pin system. Furthermore, staples or cancellous screws with spiked washer are used to provide additional support. Implementing a system similar to cross pin system on the tibial side or executing outside-tunnel fixation without using interference screws may hamper tendon bone healing less. [17]

The same study also aimed at demonstrating that fixation of hamstring graft on the femoral side immediately at tunnel orifice was more advantageous to distant fixation methods such as EndoButton. However, neither of the methods was observed to be superior to the other. When the approaches were compared in terms of tunnel enlargement, it was observed that tunnel orifice enlargement was observed when screws were used as well. They proposed that this may be attributed to micro movement, synovial fluid and difficulty of the surgical techniques.[17]

Hame et al. investigated the efficacy of notchplasty and reported that a certain amount of notchplasty, even if very limited, was required to provide the most suitable placement in the tunnel. Similarly, Horner et al. stressed the importance of notchplasty in preventing graft jamming and providing favorable tunnel placement. Taşer underlined that notchplasty had to be performed until posterior border of the notch could be seen. Taşer also pointed out that if graft jamming occurred in the roof of the notch after the placement of the graft, that part had to be removed shaved as well. All our patients underwent notchplasty in this present study. In narrow notches, lateral wall of the notch has to be removed shaved as well, to prevent graft jamming. As Hame et al. emphasized, an unexaggerated amount of notchplasty is essential in preventing early loosening.[4,6,18,19]

Klein et al. measured femoral tunnel width in patients they operated by using femoral cross pin. The mean Lysholm score for 27 patients after an 18-month follow-up was reported to be 92.6. According to IKDC scoring, 11 patients were categorized into group A, 13 patients were categorized into group B and 2 patients were categorized into group C. Their clinical results are similar to the ones we observed in our current study. Klein et al. reported in the same article that all their patients were observed with some degree of tunnel enlargement, but the enlargement was not consistent with the clinical results. Tunnel widening was not reported to be associated with "bungee" rope or "windshield wiper" effect but it may have been associated with the fact that the loosening around the cross pin might have resulted in pressure being applied to the walls around the graft. The patients in our present study were not evaluated in terms of tunnel enlargement. However, standard lateral graph images taken at 1 meter at the 12th month revealed images suggesting tunnel enlargement of various proportions.

In conclusion, autogenous four-strand hamstring tendon graft and cross pin femoral fixation of that graft yielded a significantly high rate of success in reconstruction of ACL in patients who do not participate in high activity sports, who do not have (+4) pivot-shift instability, who do not have general articular laxicity and chronic medial laxicity. We maintain that reconstruction of ACL by utilizing cross pin fixation system and four-strand hamstring tendon is a successful approach and it should be an approach of choice for indicated patients.

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