RESEARCH ARTICLE

Clinical Outcome of Anatomical Transportal Arthroscopic Anterior Cruciate Ligament Reconstruction with Hamstring Tendon Autograft

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Abstract

Background: Good clinical outcome and return to sport and daily functions after anatomical arthroscopic anterior cruciate ligament (ACL) reconstruction is goal standard in this surgery. but to date, there are different challenging issues between orthopedic surgeons regarding graft selection and surgical techniques.

Methods: We retrospectively reviewed the patients who underwent anatomical arthroscopic one bundle ACL reconstruction with quadruple hamstring tendon autograft from 2010 to 2016 in our orthopedic sport medicine center. Eighty-two eligible patients (82 knees) who had met our inclusion criteria were examined in terms of knee stability by clinical examinations and KT 2000 arthrometer and - also were evaluated regarding variables related to their health and knee status with a mean 48months follow-up.

Results: Seventy-seven patients (93.9%) were male and the other 5 cases (6.1%) were female. The mean age was 33 ± 8.06 years old at the time of surgery and mean BMI amount was 26.81 ± 3.72. 78 patients (95%) returned to pre-injury sport activity level after ACL reconstruction and two patients (2.4%) had re-rupture. 63 patients (76.8%) had negative anterior drawer and 67patients (81.8%) negative lachman tests respectively. 10 patients (13%) were found to have positive pivot shift tests which was correlated with pain and a less KOOS scores with a significant difference (*P= 0.03*). 72 patients (87%) had negative tests in active and 70 (85.4%) had less than 3 mm side to side difference in manual testing by KT2000. Final KOOS score was 70.87 ± 19.76. Mean Lysholm score was 90 ± 4.77. Mean International Knee Documentation Committee (IKDC) score of this study was 85 ± 14.11. Patients who had concomitant partial meniscectomy had significantly lower IKDC scores (*P<0.01*).Mean kujala score was 79 ± 3.07.

Conclusion: The use of quadrupled hamstring tendon autograft besides the most important part of the treatment which is the surgical technique would yield to excellent results in ACL reconstruction both subjectively and objectively. In addition, patient selection and surgeon's experience should be considered in determining the treatment plan for the patients.

Level of evidence: IV

Keywords: ACL, Allograft, Hamstring tendon, Reconstruction

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Introduction

Anterior cruciate ligament (ACL) is an important structure- related to dynamic and static forces in the knee joint and it's rupture is one of the most common injuries of the knee. About 250,000 ACL rupture occur in the United State each year and almost 100,000 ACL reconstruction are performed annually (1, 2). Patients with a rupture of ACL may report pain, difficulty with athletic performance and/or giving-way symptoms in daily activities (3-5). ACL rupture may lead to knee laxity, resulting in functional instability and increased risk of meniscal injury, chondral lesions - and degenerative joint disease (6-10).

With the perfection of arthroscopic equipment, improvement of technology and advancement of basic research, arthroscopic ACL reconstruction has become a standard remedy for its favorable clinical effectiveness. However, there are still disputes within the published literature over the last 20 years regarding graft selection (11, 12).

Despite highly success with autologous patellar tendon graft, concerns still remains regarding morbidity in donor-site and patellar function problems. So the use of triple- or quadruple-stranded hamstring tendon grafts for anterior cruciate ligament reconstructions has increased in popularity with less surgical site complications and high tensile load (13, 14). Quadruple-stranded graft also provides a multiple bundle replacement graft that may better approximate the function of the two-bundle anterior cruciate ligament (15). Disadvantages of this soft tissue graft include the concern over tendon healing within the osseous tunnels and the lack ofrigid bony fixation (16).

Other advantages include smaller incision needed for graft harvest, less perioperative pain, less anterior knee pain and high maximum load to failure (17, 18).

Increased understanding of technical issues of graft selection, placement, tensioning, and fixation as well as of postoperative rehabilitation led to dramatically improved results compared with previous intraarticular reconstructions (19, 20). There are controversies regarding the clinical outcome and return to previous activity level in reported studies and the literature lacks enough research on this subject (21, 22).

Materials and Methods

The study design consists of a retrospective review that included all patients who had undergone anatomical arthroscopic ACL reconstruction with quadruple hamstring tendon secured with endobuttom and absorbable fixation system by our senior surgeon. Exclusion criteria were all patients suffering injury to other ligaments besides ACL such as MCL,LCL or PCL ,huge full-thickness cartilage damage of knee ,extensive meniscus tear , revision reconstructions concomitant distal femur or proximal tibia corrective osteotomy or fracture .

After our institutional review board approval (Code number 930971) we reviewed the eligible ACL reconstructed patients who had undergone surgery between 2010and 2016. All patients received consent form and filled out them. Among 100 patients who were contacted 82 patients met the inclusion criteria for our study and were also willing to cooperate.

All of the 82 patients (with at least 12 months after surgery) were invited to hospital and were examined clinically by one of the authors who had not participated in the surgery regarding objective tests; Lachman test ,pivot shifting test and also instrumental testing by KT 2000 arthrometer. All patients filled subjective forms including the SF36, KOOS, IKDC, Kujala and Lysholm questionnaires (23-27). about anterior drawer test If the tibia translates more than 5 millimeters anteriorly on femur it means positive and otherwise it would be negative. The Latchman test was graded as 0 (<3mm), 1(3-5mm) ,or 2(>5mm) and pivot-shift test was graded as 0(negative), 1(mild or glide), 2(moderate or clunk) and 3(severe or gross subluxation).as we included only isolated ACL tear ,we had only negative(grade 0) or positive (grade1) in this study. In IKDC score grade A is considered to be 'Normal', grade B 'Nearly normal', grade C 'Abnormal' and grade D 'Severely abnormal'. Scoring in Lysholm test is "excellent" when 95 to 100 and "good" between 84 to 94.

Data were expressed as mean ± SD. We used ROC for analysis of quantities data and ANOVA and chi-square test for analysis of qualitative data. In all testing of hypothesis, the level of significant was 0.05. All data were analyzed using IBM SPSS Statistics version 16 statistical software.

Our Operative Technique

Before the start of reconstruction, complete evaluation of the knee using arthroscopy had performed for treatment of cartilage damage mainly by microfracture or multiple drilling and also meniscus preservation if required. After semitendinosus and gracilis graft harvest with small medial incision in antromedial of the knee. Grafts were prepared in a quadruple manner and also underwent 20 mintues of 50 Ib tension by a Smith &Nephew tension device. We did not try to clean the joint from ACL remnant and all these remnants were preserved although viewing the anatomical foot print of the femoral side somehow difficult with this policy. By using a transportal technique via a medial accessory portal we always tried to see the femoral foot print directly and lowering the position of the femoral tunnel to a more anatomic position both posterior and inferior , to mimic anatomic foot print and finally achieve better control of rotational instability in the knee.

Tibial foot print was considered anteroposteriorly at the anterior root of lateral meniscus and closer to medial eminence in coronal plan.

Graft in quadruple fashion passed and fixed in femoral side with endobuttom and in tibial side in knee extension with absorbable screw in 2 mm larger than tunel diameter (Smith & Nephew) [Figure 1; 2].

patients were permitted to bear weight with crutches

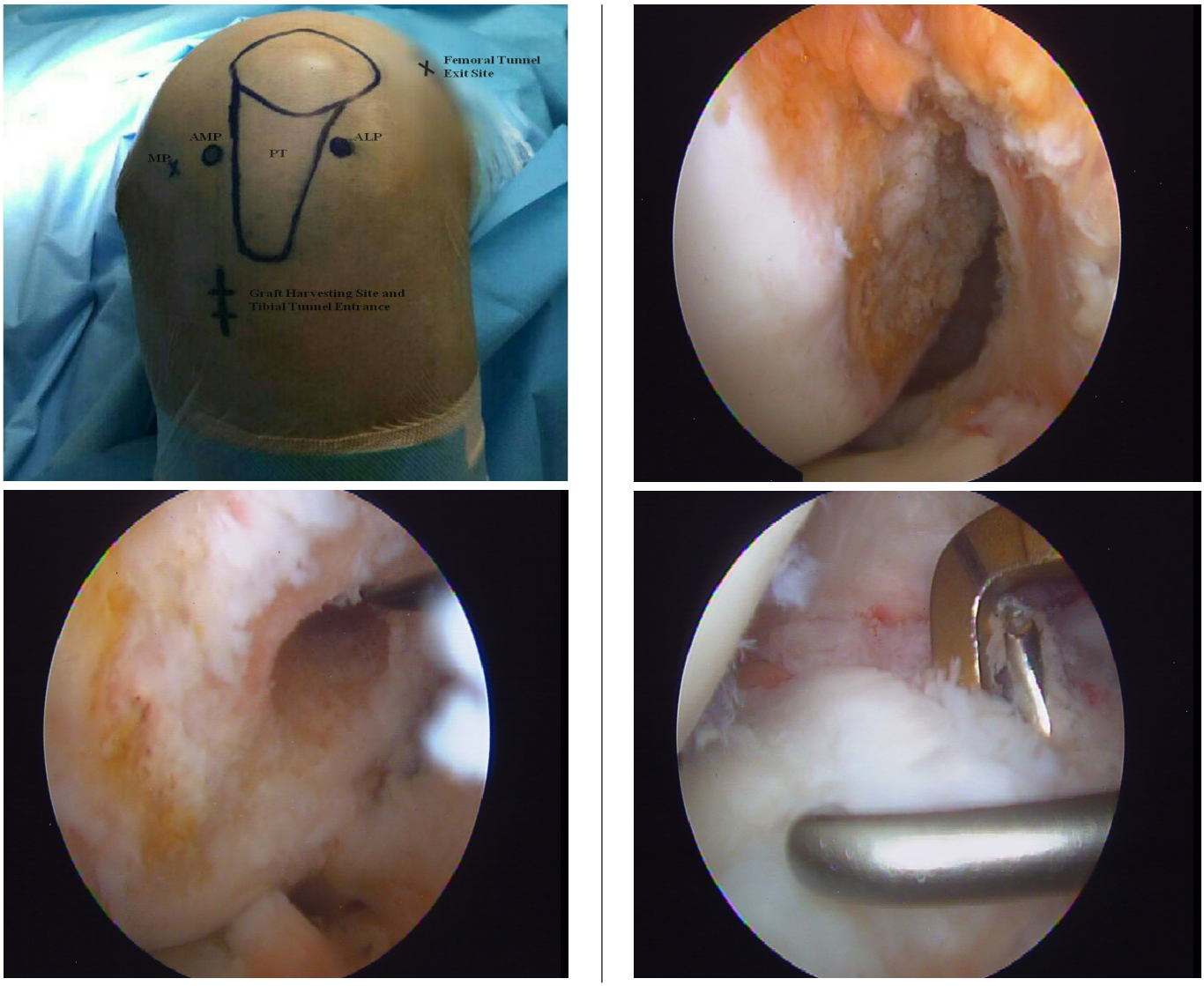

Figure 1. ACL tear assessment. Limited remnant shaving and tunnel placement.

the day after surgery and start a regular programme of rehabilitation till 3 months.

Results

We studied, 100 patients with documented isolated ACL tear (by physical examination and MRI) that had underwent anatomic arthroscopic ACL reconstruction with quadruple hamstring autograft from 2010 to 2016. Finally 82 patients met our inclusion criteria and came to our clinic for follow up. From other, we couldn't find around 10 patients and 8 patients reported being well but didn't participated in our study. The data from clinical examinations and KT 2000 apparatus and questionnaires filled by the patients.

77 patients (93.9%) were male and the other 5 cases (6.1%) were female. The youngest case was 19 years old and the oldest one was 59 and the mean age was 33 ± 8.06. Mean BMI amount was 26.81 ± 3.72 (range 18 to 36.5). In 52 patients (63.5%) the left knee was injured and in 30 (36.5%) the right knee was injured. The mean follow up time was 36.34 months with a standard deviation of 17.95 months (range 12 to 60 m) [Table 1].

The mechanism of injury was studied indicating that 68 (82.9%) had sport related injuries, 9 (11%) had motor vehicle accident and 5 (6.1%) had falling. Of sport injuries 51 cases occurred during soccer game, 10 cases during martial arts, and 7 were related to other sport categories.

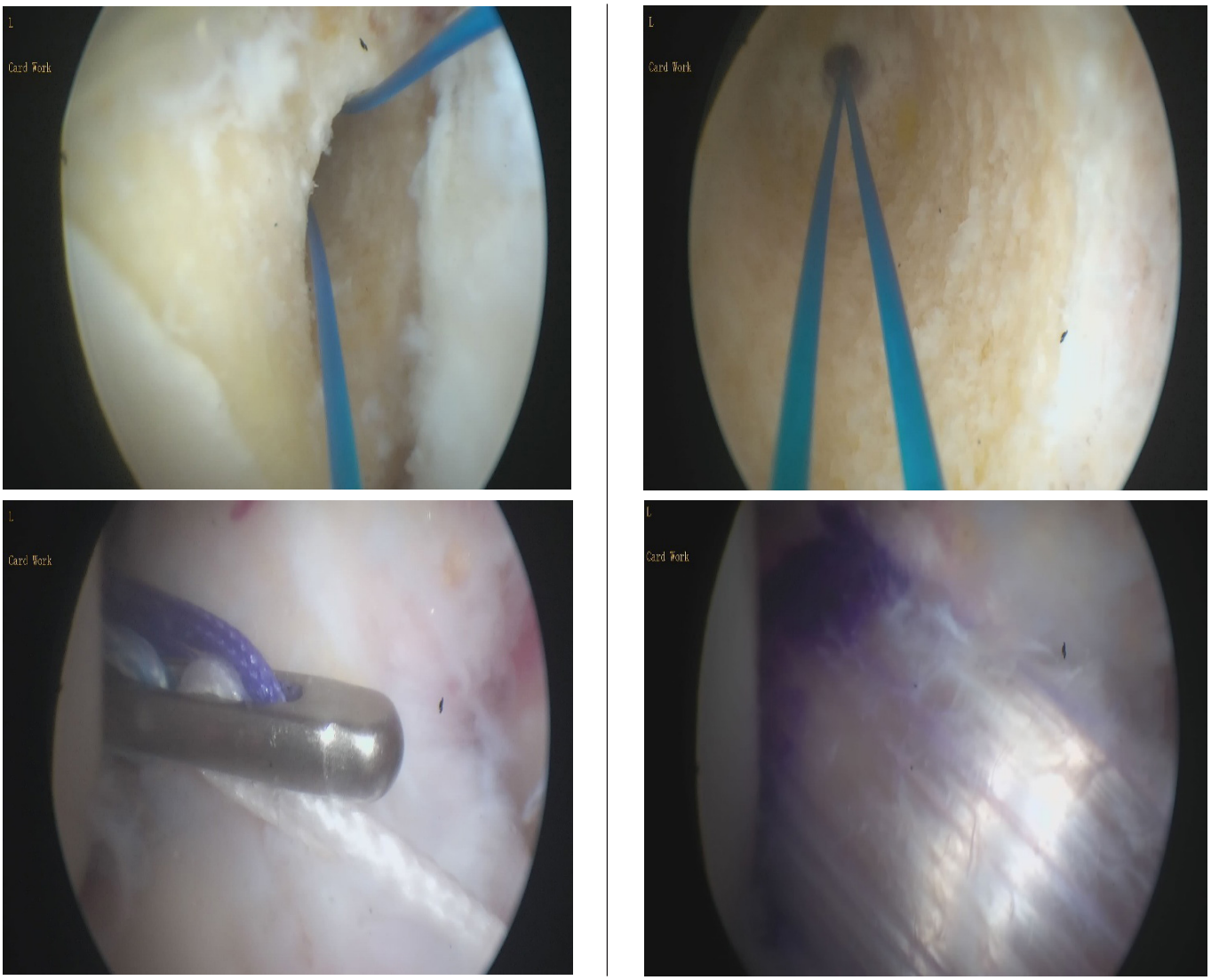

Figure 2. Femoral tunnel assessment from opposite portal and graft passage.

Table 1. Demographic features of the patients	
Total patients	82
Male/Female	77/5
Age	33 ± 8.06 y (19-59)
BMI	26.81 ± 3.72 (18.2 -36.5)
Side (L/R)	52/30
Follow up	36.34 m (12-60)

Based on statistical analysis age was not related to post ACL reconstruction laxity. Mann-Whitney test did not show significant relationship between age and stability tests including lachman and active and manual KT 2000 apparatus (*P=0.68*).

51% of patients mentioned giving way before surgery as their chief complaint and the rest mentioned other symptoms. After surgery anterior knee pain was present in 7(8.5%), kneeling pain in 5(6.09%) graft site pain was reported by 5(6.09%) of patients and 3 (3.65%) of patients had difficulty with squatting or unable to squat. 2 patients complained of some degrees of motion limitation [Table 2]. 64 patients (78%) returned to pre-injury activity level after ACL reconstruction.2 patients had re-rupture in follow up study.

The mean mid thigh diameter difference is 1.34 ± 1.19. 68 patients (83%) had a diameter of less than 2 cm and 14 patients (17%) 2 cm or more [Chart 1]. Analysis showed thigh diameter difference with uninjured

Table 2. Evaluation of reported symptoms by patients					
Subjective symptoms	**Anterior knee pain**	**Kneeling pain**	**Graft site pain**	**Difficult squatting**	**Decreased ROM**
+	7(8.5%)	5(6.09%)	5(6.09%)	3(3.65%)	2(2.44%)
-	75(91.5%)	77(93.9%)	77(93.9%)	79(96.35%)	80(97.56%)

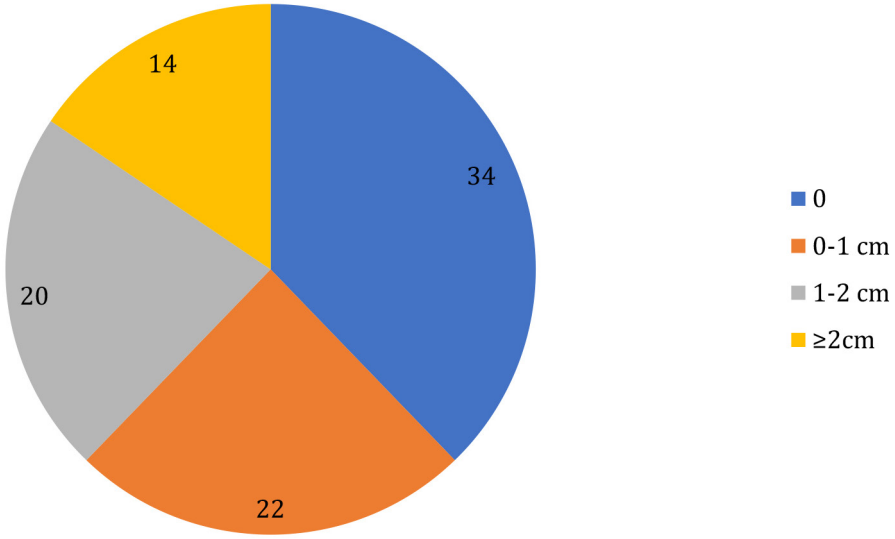

Chart 1. The difference in mid thigh diameter with contra lateral side.

Table 3. Results of objective tests		
Objective tests	**posetive**	**negative**
ADT	19 (23.18%)	63 (76.82%)
Latchman	15 (% 18.2)	67 (81.8%)
Pivot-shift	10 (13%)	72 (87%)

contra lateral side correlates with knee pain (*P=0.03*). about associated procedures 18 patients had partial meniscectomy (less than 1/3) and 9 had multiple drilling for small cartilage damage.

In our study 19 (23.18%) of operated knees were positive and 63 (76.82%) were negative with anterior drawer test.15 patients (18.2 %) had positive (grade 2) and 67 patients (81.8%) had negative lachman tests.

Ten patients (13%) were found to have positive pivot shift tests which was correlated with pain and less KOOS scores with a significant difference (*P= 0.03*) and 72 patients (87%) had negative tests [Table 3].

KT arthrometer assessment is done in 3 ways as passive, active and manual. Passive anterior translation test by KT 2000 arthrometer is calculated after measuring the translation of both knees after applying 10, 20, 30 and 35 Ib force to each knee of the same patients. If the difference between translation of knees were less than 3 mm it would be considered as stable knee and if the difference is equal or more than 3 mm it would be considered as laxity of the operated knee [Chart 2].

In active testing we had 67 (81.7%) patients with less or equal 3 mm translation and 15 (18.3%) with more. The mean side-to-side difference on the KT-2000 maximum manual force test was 1.67 mm ± 1.52 and 70 patients (84.4 %) had side to side difference of less than 3 mm and other 12 had 3 mm or more. A significant correlation was detected (*P=0.02*) indicating susceptibility of patients with BMI more than 25 to knee instability after ACL reconstruction [Table 4].

The Short Form (SF36) Health Survey (patient-reported) was filled by each patient and in physical functioning item, the score was 70.27 and in general health perception 67.38 [Table 5].

results of patients KOOS scores (to assess short and long-term patient-relevant outcomes following knee injury) indicate the patients have good knee function with final KOOS score of 70.87 ± 19.76 [Table 6].

In this study the mean Lysholm score was 90 ± 4.77(range37to100).56 patients (68%) had excellent (95-100) or good (84-94) results [Chart 3]. The mean IKDC score of this study was 85 ± 14.11(range29 to 96).

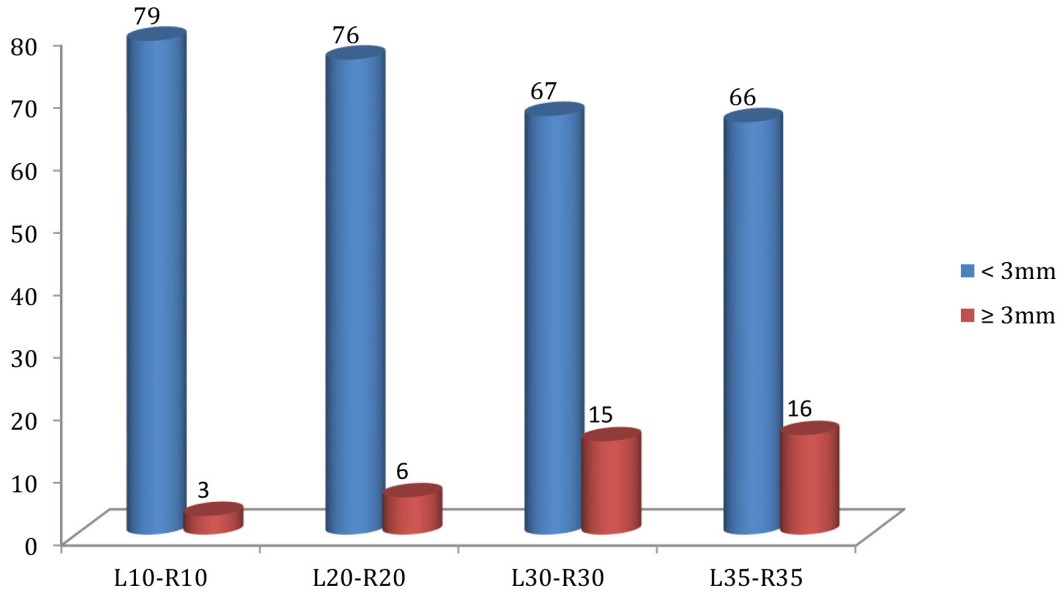

Chart 2. Difference of anterior knee instability of both knees by 10, 20, 30, and 35 Ib.

Table 4. Relationship between BMI and manual SSD				
		BMI < 25	BMI ≥ 25	total
Manual SSD	mm 3 >	60	10	70
		85.7%	14.3%	100%
	mm 3 ≤	4	8	12
		33.4%	66.6%	100%
	Total	64	18	82
		78%	22%	100%

There were no significant correlation between sex and IKDC or Lysholm scores but in patient with associated surgery on menisc or cartilage we had lower scores in IKDC. The Kujala scoring questionnaire consists of 13 questions designed to assess anterior knee pain in various knee positions. The mean kujala score of this study was 79 ± 3.07.

Based on statistical analysis 79 patients had no surgical complications after reconstruction, 1 patient had cyst formation on tibial site of interference screw after 1 year follow up, and 2 had rerupture (2.4%) due to new injury, both of which were during soccer playing.

Table 5. Patients' health status questionnaire (SF36)										
	PF	RP	BP	GH	VT	SF	RE	MH	PCS	MCS
Mean	70.27	52.71	66.70	67.38	71.36	78.26	62.21	75.31	45.33	51.15
Standard deviation	25.43	37.64	25.23	20.71	1.80	21.63	42.84	17.01	12.29	9.29

Table 6. Patients KOOS scores						
	KOOS Symptoms	KOOS Pain	KOOS ADL	KOOS Sport/Recreation	KOOS QOL	KOOS Final
Mean	71.32	73.42	73.96	54.04	49.01	70.87
Standard deviation	20.38	20.25	23.79	30.02	24.06	19.76

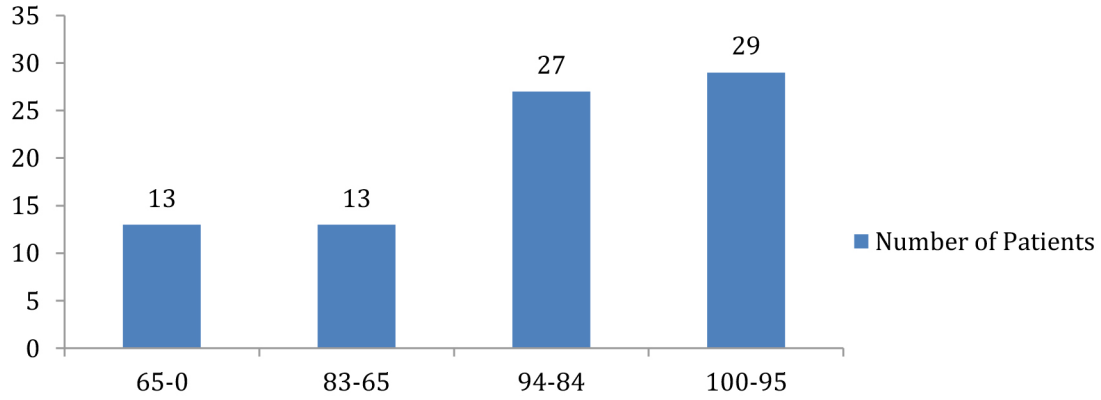

Chart 3. Frequency of Lysholm score.

Discussion

The goals of ligament surgery are to restore normal joint motion, return to full function and prevent secondary injury and joint arthrosis. Although Some studies have reported excellent stability after hamstring tendon graft reconstruction but some had high laxity rates (16, 17, 28, 29). Nonetheless quadruple hamstring graft have become more popular todays with fewer patellofemoral complications ,extensor mechanism damage or allograft concerns .It is completely logical that a more stable knee is achieved by reconstructing the ACL anatomically and less complication and morbidity is to be encountered by doing it arthroscopically that is less invasive (30).

Autografts are considered to be safe with no risk of disease transmission and immunological reactions. There is still debate regarding the selection of a more long standing, strong graft which would accompany less graft harvest morbidity (31). According to reasons mentioned above the purpose of this study is to evaluate the clinical outcomes of anatomical arthroscopic ACL reconstruction with quadrupled hamstring autograft. The main findings of this study showed stable knees and excellent results with fractional morbidity and a fast return to pre-injury level could be achieved by using hamstring tendon autograft.

Regarding knee stability, 15 patients (18%) had positive lachman test. Gifstadt reported 33% and Williams reported 11% positive Lachman (32). As techniques differ among surgeons and some of them have been used double stranded hamstring tendon instead of quadrupled graft, reports range widely. Another bias might be due to low interobserver reliability of lachman test (32).

The mean side-to-side difference on the KT-2000 maximum manual force test was 1.67 mm ± 1.52 and 70 patients (84.4 %) had side to side difference of less than 3 mm that is comparable with previous studies. Gifstad reported 1.4 mm ± 1.4 side to side difference on KT1000 (33). In a study by Beynnon et al a side-to side difference of more than 3 mm was observed in three of the patients. The patients in whom a hamstring graft had been used had an average of 4.4 mm of increased anterior knee laxity compared with the laxity of the contralateral, normal knee (34). The KT-2000 arthrometer mean side-to-side difference for manual maximum displacement was 2.03 mm (range, -1 to 8) and 3.1 ± 2.3 mm for Charlton's and Anderson's papers respectively (29, 31). freedman also reports 73.8% side-to-side difference of less than 3 mm (16). most studies have reported less than 3mm side to side difference on KT in about70% or more of their patients and the mean varies mostly between 2 and 3mm (35, 36).

In this study 72 patients (87%) had negative pivot shift test which indicates high rate of knee stability. There was a significant assossiation between pivot shift test and patients satisfaction and knee scores (*P=0.03*). but we did not find such an assossiation between lachman and arthrometer findings and pain and knee scores. other studies report varying rates regarding pivot test mostly ranging from 70 to 84% negative pivot test (34, 37). Mininder stated that Instrumented knee laxity and Lachman examination had no significant relationships with any subjective variables of symptoms and function. But Pivot-shift examination had significant associations with satisfaction on the other hand Peterson et al found no statistically significant difference for the presence of pain, giving way, effusion, Lachman and pivot shift results, or arthrometer measurements (37, 38). The pivot-shift examination may be a better measure of "functional instability" than instrumented knee laxity or Lachman examination after anterior cruciate ligament reconstruction (37).

The results of lysholm score were mostly good or

excellent with a mean of 91 similar to other reports including Gifstad et al, Charlton et al and Williams et al and many others who reported a lysholm score of about 90 (28, 32, 33). the mean international knee Documentation Committee knee score was 85 slightly better than charlton's review with IKDC of 83 (28).

The most common postoperative complications after ACL reconstruction are motion (primarily extension) deficits and anterior knee pain. The incidence of these complications is difficult to determine from the literature, with reported frequencies of motion loss ranging from 1% to 13% and of postoperative pain ranging from 0% to 34%. The cause of arthrofibrosis is not fully understood but the most common causes are reported to be bad surgical technique and poor rehabilitation (39). the best treatment of loss of motion is to avoid it with proper postoperative rehabilitation involving early return to full range of motion (40).

Two patients (2.5%) had loss of 5 degrees of flexion and there was no patient with extension lag in this study. Aglietti et al. found that an extension loss of 3 degrees 3% in their DLSG (outcome of arthroscopic ACL reconstruction with hamstring autograft) group an extension deficit of five degrees or more was observedin three patients (8%) in the DLSG group (34). A flexion deficit of fivedegrees or more was observed in six patients (17%) in theDLSG group (33).

In this study the frequency of pain was 8.5% (7 patients) with mean follow up of 3 years that is higher than 3% reported by Gifstad after 7 year follow up but less than 11% reported by Freedman et al (16, 32). Our statistical analysis and other studies indicate that the frequency of pain decreases over time with increasing follow up date. In this study patients with more than 3 years of follow up reported no pain.

Harvest of the hamstring tendons has raised concerns about potential weakness of knee flexion. Most studies have reported no significant difference in hamstring muscle torque between the surgical extremity and the control extremity at 2 years after surgery, possibly because of regeneration of these tendons, as shown in MRI studies by Rispoli et al (41). In this study Fourteen patients (17%) has mid thigh diameter difference of 2 cm or more with a mean of 1.33 ± 1.19cm and there was a correlation between the mid thigh difference and pain scores. After surgery, the thigh muscles atrophy is quick. Studies revealed that maximal thigh atrophy was recorded 6 weeks after surgery. In another study the contralateral thigh girth difference was a mean of 4.2 cm (20). the thigh diameter difference could be due to quadriceps atrophy which is common in ACL reconstructed patients and not the hamstring tendon that has been shown to regenerate previously (41).

The successful and fast return of an athlete to his pre injury level of sport depends on the rehabilitation protocol (34). literature shows no significant association of post operative brace treatment with a better outcome (42). We have reached the same conclusion in our practice starting continued passive motion the day after surgery. Our study reports 78% (64 patients) return to the pre-injury activity level. In a study by Gifstad et al Thirty-two patients (71%) in the DLSG group classified their subjective knee function as excellent or good (33). Nineteen (82.6%) patients in a study by Kropft et al. were able to perform strenuous activity but only 10 (43.5%) of them were able to return to pre-injury activity levels in terms of frequency and type of acivity (43). Anderson et al and sajovic reported 78% and 81% of return to pre-injury level respectively (31, 44). there is not a consistent reported rate of return to sport in literature (35, 37).

Only 2 patients out of 82 (2.4%) had graft failure due to new sport injury in this study which is less than previously reported graft failures. Gifstad et al reported re-rupture rate of (6%). (33) Sajovic et al. (44) found an ACL revision rate of 7% and Pinczewski et al. (45) reported 13% revisions. Three patients (4%) had a positive pivot shift test but had no history of additional trauma to the knee. Six patients (7%) had a traumatic rupture of the graft. The overall rate of failure was 11% (31). The rate of graft failure was 4.9% in freedman report (16). graft failure rates 4.1% for hamstring grafts (46).

This study indicated minimal morbidity after hamstring autograft harvest and also excellent clinical and arthrometric stability with improving high knee scores. In patients with BMI less than 25, negative pivot shift test we expect to have great subjective and objective satisfactory results.

In addition to graft type, patient selection and surgeon's experience with reconstruction technique to be used are also of paramount importance.

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