

Original Research Article

Comparison between functional outcome of arthroscopic anterior cruciate ligament reconstruction using single bundle six fold and four fold semitendinosus and gracilis graft

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ABSTRACT

Background: With increase participation in sports activities, anterior cruciate ligament (ACL) tear is a common and functionally disabling injury. Hamstring tendon as autografts for arthroscopic ACL reconstructions have shown good clinical and functional outcome in patients. The purpose of present study was to compare the functional outcome of arthroscopic Anterior Cruciate ligament (ACL) reconstruction using single bundle six fold and four fold ST and G graft.

Methods: This was a prospective study conducted between period June 2008 to December 2010. 181 patients undergoing ACL reconstruction were screened and 113 patients fulfilling the inclusion exclusion criteria were selected for the study.

Results: All patients completed a minimum of 1 years follow up. In 4 fold group 27.50% were having grade 1 anterior drawer test 22.50% were having grade 1 Lachman test and 17.50% had grade 1 pivot shift test as compared to 6 fold group 6.66% had grade 1 anterior drawer test, 11.66% had grade 1 Lachman test, and 3.33% had grade 1 pivot shift test respectively which was statistically significant ($p < 0.05$).

Conclusions: Arthroscopic ACL reconstruction using six fold graft is effective modality of treatment in patient with ACL deficient knee. Six fold graft is thicker in diameter and cross sectional area as compared to four fold graft which occupies more surface area of normal ACL foot print and gives better stability of knee joint in both AP and rotational plane.

Keywords: ACL, Arthroscopic evaluation, Single bundle, Graft

INTRODUCTION

With increase participation in sports activities, anterior cruciate ligament (ACL) tear is a common and functionally disabling injury.^{1,2} Advances in Arthroscopic techniques and reliable fixation devices have led to more favourable results.³ The bone-patellar tendon-bone (BPTB) and hamstring tendon autografts are the most common autografts in ACL reconstruction.^{4,5} Autogenic

grafts are the most frequently used grafts for ACL reconstruction and it has consistently yielded positive and effective results.^{6,7} The incidence of patients undergoing ACL reconstruction has increased. Graft selection in ACL reconstruction is one of the most crucial decision.⁵ Selection of graft generally depends on the surgeon's expertise and preference, tissue availability, patient activity level, presence of co morbidity, prior surgery.⁸ Hamstring tendon as autografts for arthroscopic ACL

reconstructions have shown good clinical and functional outcome in patients.⁵ The BPTB autograft has given excellent clinical results and high level of patient satisfaction after a long term follow-up.^{6,9} In vitro studies have been proven hamstring grafts to be as strong as the original ACL.¹⁰ But some authors have reported inferior stability in vivo compared to BTB grafts.¹¹ BPTB graft has been associated donor site morbidity, such as patellofemoral osteoarthritis, patellar tendon shortening, loss of terminal extension, and patellofemoral pain.^{7,12} When compared to BPTB graft, use of hamstring tendon graft are reported to have relatively more knee laxity, weakness in deep flexion, the development of flexion deficit and an increased risk of tunnel widening.^{10,13,14} Hamstring grafts are relatively thinner than the bone patellar bone grafts and may also be associated with wind shield wiper and bungee effects.^{15,16} Six fold graft technique have been reported in recent studies. Laoruengthana showed that increasing cross-sectional area of hamstring tendons by using 6-strand graft can improve knee stability and patient's activity in the early clinical outcomes so, by further increasing the folds and using a six fold tendon graft might decrease the incidence of such complications. Also a six fold graft will have a larger cross sectional area and will be biomechanically more strong thus improving the knee stability.^{17,18} The purpose of present study was to compare the functional outcome of arthroscopic Anterior Cruciate ligament (ACL) reconstruction using single bundle six fold and four fold semitendinosus and gracilis graft.

METHODS

A retrospective study with prospective follow up to compare the results of 4 fold and 6 fold tendon graft was conducted between period June 2008 to December 2010 at Sancheti institute for orthopedics and rehabilitation Pune. 181 patients undergoing ACL reconstruction were screened and 113 patients fulfilling the inclusion exclusion criteria were selected for the study. Out of 113 patients 35 patients underwent ACL reconstruction using fourfold graft and 78 patients underwent ACL reconstruction using six fold graft. Inclusion criteria for surgery were patients with ACL tear who have completed 6 weeks of conservative management and still complaining of instability while walking or running, episodes of locking were selected to undergo ACL reconstruction. Patients fulfilling above criteria were included in the study. Patients with associated grade 3 and Grade 4 medial collateral ligament and lateral collateral ligament injury or avulsion fracture, previously operated cases, ACL injuries associated with fractures including avulsion fractures, associated posterior cruciate ligament or posterolateral corner injury, grade 3 and Grade 4 osteochondral defect, and patients suffering from diagnosed prior knee pathology e.g., stiffness, osteoarthritis were excluded from study. This protocol was reviewed and approved by an Independent Ethical committee.

Statistical data analysis

Statistical data analysis done by using SPSS 17.0, Minitab 15.0 statistical softwares and MS-excel. To find the significance in various parameters we have used 2 independent sample t-test, paired t-test 2 sample proportion test, Wilcoxon sign rank test and Mann Whitney test. The comparison analyzed at 5% level of significance.

Surgical technique

Arthroscopic evaluation was done through standard surgical technique using anteromedial and anterolateral portals. Other associated meniscal injuries were noted and complete ACL tear was confirmed. After confirming ACL tear, 5 cm longitudinal incision over the pes anserinus was taken semitendinosus and gracilis tendon were identified and harvested with tendon stripper (Figure 1).



Figure 1: Two fold of semitendinosus tendon and single fold of gracilis graft.

The length of semitendinosus and gracilis tendon was ranging from 30 ± 2 cm (26 to 34 cm) and 22 ± 1.5 cm (17 to 28 cm) respectively. The grafts were prepared to 6-strand or 4 fold with vicryl No.1 sutures, and distally with Ethibond and after that proper sizing of the graft were done (Figure 2 and 3).



Figure 2: Graft folded in to six fold.



Figure 3: Final sizing of the graft.

The average length and diameter of six fold graft was 7.53±0.2 cm (7.2 to 7.8 cm) and 9.73±0.5 mm (9-11 mm) respectively. Similarly the average length and diameter of four fold graft was 7.41±0.3 cm (7.1 to 7.7 cm) and 8.11±0.3 mm (8–9 mm) respectively. Tibial entry point was taken using tip aimer 6 to 7 mm in front of PCL and tunnels were made. Tibial tunnel length was between 30 to 40 mm. After tibial entry was made, femoral notch was cleared and prepared, resident’s ridge and transverse ridge were identified for femoral entry. Femoral entry point was behind the resident’s ridge and inferior to transverse ridge. This was again confirmed through antero medial portal and then transtibial drilling was done with knee in 90 degree of flexion or through AM portal keeping 2 to 3 mm of bone behind. Average femoral tunnel length was 40±5 mm (30 to 45 mm). Graft was fixed at femoral side with endobutton CL and at tibial side with interference screw (BioScrew).

Postoperative rehabilitation protocol and evaluation

Same physiotherapy protocol was followed for patients in both the group. Postoperatively long knee brace was given for period of 3 weeks. Partial weight bearing started on second day with the help of crutches and full weight bearing walking after 3 weeks. Gradual knee bending exercises and muscle strengthening exercises

were started from day 2. Final evaluation was done when the last patient in the study completed one year follow up. All patients were then called for final follow up and final assessment including knee pain, knee range of motion, laxity, hamstrings and quadriceps muscle strength was done. Functional scoring was done at the same time using Lysholm score, IKDC score and grade for stability and VAS score for pain.^{19,20} Return to preinjury activity level was also asked and noted.

RESULTS

Average age in 4 fold group was 29.6±10.3 (17-52 years) and in 6 fold group was 30.62±7.49 (16-51 years). Out of 35 patients in 4 fold group there were 30 male and 5 female patients and out of 78 patients in 6 fold group there were 71 male patients and 7 female patients. Mode of injury in 4 fold group was slip and fall in 13 (37.14%) patients, twisting injury while playing in 12 (34.29%), and direct trauma in 10 (28.57%) and in 6 fold group slip and fall in 23 (29.49%) patients, twisting injury while playing in 39 (50.0%) patients and direct trauma in 16 (20.51%) patients Average duration between injury and surgery was 7.86±8.36 months (6 weeks- 36 months) in 4 fold group and 10.30±15.10 (2-60 months) months in 6 fold group (Table 1).

Table 1: Demographic distribution of patients in both the group.

Variables	4 fold	6 fold	Statistically significant
Age	29.6±10.3	30.62±7.49	p=0.591
Sex(male/female)	30/5	71 /7	p=0.431
Mode of injury	Slip and fall	13	23
	Twisting injury	12	39
	Direct trauma	10	16
Duration of injury (months)	7.86±8.36	10.30±15.10	p=0.27
Preoperative pain	Present	18	40
	Absent	17	38
Postoperative range of motion (degree)	135.00±5.29	139.10±3.58	p<0.001

All patients completed a minimum of 1 years follow up with mean follow up of 15±4 months (11 to 19 months) no patients were lost to follow up. Average postoperative range of motion (ROM) in degree in 4 fold group was 135±5.29 (130 to 140 degree) and in 6 fold group it was 139.10±3.58 (135 to 140), which was statistically significant using 2 sample proportion test (p<0.05) but when compared to pre and postoperative ROM (degree) in both groups, there was significant improvement in postoperative ROM in both groups with p<0.05. The mean length of the graft was 8.33±0.2 cm (7.8-8.6 cm) and the mean diameter of six fold graft was 9.73 mm (9-11 mm) and four fold graft was 8.11 mm (8 to 9 mm). Follow up at the mean period of 15 months, evaluation of anterior-posterior knee laxity with standard laxity test (anterior Drawer and Lachman test) and pivot shift test

was done. In 4 fold group 27.50% were having grade 1 anterior drawer test 22.50% were having grade 1 Lachman test and 17.50% had grade 1 pivot shift test as compared to 6 fold group 6.66% had grade 1 anterior drawer test, 11.66% had grade 1 Lachman test, and 3.33% had grade 1 pivot shift test respectively which was statistically significant (p<0.05). But when compared to pre and postoperative knee stability in either group there was significant improvement in postoperative knee stability in both the groups.

Patient subjective assessment

There was no significant difference in VAS score in both groups with p>0.05, but there was significant improvement in pre and postoperative VAS score in both

groups. Both Lysholm score and IKDC score was significantly better in 6 fold group 88.17 ± 4.43 (69-96) and 87.53 ± 2.90 (80.32-93.26) as compared to 4 fold group 74.29 ± 6.17 (64-89) and 74.83 ± 4.62 (64.78-82.54) but when compared to pre and postoperative Lysholm score and IKDC score, postoperatively score was improved in both the groups. Similarly there was significant improvement in IKDC grade in 6 fold group (70 pts grade A and 8 pts grade B) as compared with 4 fold group (3 pts grade A and 31 pts grade B and 1 pt grade C), but as compared to pre and postoperative IKDC grade, there was significant improvement in postoperative IKDC grade in both the groups. All patients returned to their preinjury activity level within 1 year post surgery, however patients treated with six fold graft returned to their pre injury level after 6 to 8 months as compared to 8 to 10 months who were treated with four fold.

DISCUSSION

During the past decade, there has been an increased use of hamstring grafts with multiple strands to reconstruct the anterior cruciate ligament.^{10,11,21,22} The results of ACL reconstruction depend on various factors like preoperative activity level of the patient, muscle strength, associated injuries, and postoperative rehabilitation²³. Variations in operative techniques may also affect the outcome, like use of different graft, single or double bundle reconstruction and graft size.²³ This trend is believed to be related to improved fixation techniques and the perception that hamstring grafts are associated with less morbidity than patellar ligament grafts.^{10,11,14,21,22} Several in vitro kinematic investigations demonstrated that single-bundle reconstructions alone were insufficient in controlling the combined rotatory load and valgus torque that simulates the pivot shift test [stability paper 9, 22, 27]. Single bundle ACL reconstruction using tendon grafts has shown to have good results by many investigators.^{24,25} If tendon graft can be considered as a rope, the increase in cross sectional area will also increase the torsional strength. With this assumption, use of 6 fold graft and its comparison to 4 fold graft was investigated.

Noyes et al reported that 14mm BPTB graft represents 168% of ACL strength so, 9 or 10 mm BPTB graft would represent approximately 120% of ACL strength.²⁶ Strength of the ACL and ACL substitutes depend on the cross sectional area. He also reported ST represent 70% of ACL strength so, doubling the graft will produce 140% of ACL strength and a quadrupled construct exceed around 250% of ACL strength and six fold will definitely produce more than 300% of ACL strength. Thus four strand and six strand construct are stronger than any of the 10 mm BPTB graft and also six fold graft is stronger than four fold graft.²⁷ Another theory of improved stability of 6 fold graft may be as a function of increased coverage of the ACL foot print. Normally femoral attachment of ACL is of 11 to 24 mm in diameter and tibial attachment is around 11 mm (8 to 12 mm).²⁷

Generally a bone patellar bone graft is of 10 mm diameter and 40 mm² cross sectional area and occupies 90% area of the ACL foot print. A single bundle four fold Semitendinosus tendon graft is of diameter 8 to 9 mm and 60 to 70 mm² cross sectional area occupies 1.5 times of ACL foot print. A six fold Hamstring graft of diameter 10 mm (as noted in this study) will have cross sectional area of around 79mm² and will occupy more surface area of ACL foot print.²⁸ This may again in turn improve the stability and also more surface area will be available for tendon to bone healing with less chance of tunnel widening. Six fold grafts are thicker than the four fold grafts. In this study average diameter of 4 fold graft was 8.11 mm and 6 fold graft was 9.73 mm which will achieve better stability. Being a higher cross sectional area of 6 fold graft ultimate load to failure of this graft should be less. Study conducted by Tohyama demonstrated that anterior cruciate ligament grafts fashioned using multiple-strand (six and four strand) result in a cross-sectional area in comparison to the 10 mm bone-patellar tendon- bone graft, which is an important finding since cross-sectional area reflects the intra-articular volume of collagenous tissue.²²

Similarly study conducted by Laoruengthana et al showed average 6 fold diameter was 9.54 (8-11 mm), and Aglietti et al showed that average 4 fold diameter was 8 mm.^{13,29} Study conducted by Cross et al demonstrated apparent regeneration of the tendons of the semitendinosus and gracilis muscles after their use for anterior cruciate ligament reconstruction.³⁰ Also the results demonstrated that these tendons appear to regrow and are probably functional. There is no loss of hamstring strength in our series when it is used as a graft material which corresponds to study conducted by Lipscomb AB³¹ who demonstrated that there is no significant loss of hamstring strength occurred when the semitendinosus and gracilis tendons were used to construct the ACL.

In our series, in 4 fold group post operatively 57.12% were having positive anterior drawer test 37.14% were having positive Lachman test and 28.5% had positive pivot shift test as compared to 6 fold group 1.28% had positive anterior drawer test, 3.84% had lachman test, and 2.56% had positive pivot shift test respectively. Similarly study conducted by Chen et al demonstrated that grade 2 or higher ligament laxity with the anterior drawer test (5.1%), and 6.1% had a positive pivot shift in four fold hamstring group.²³ Also Heijne et al showed that four fold hamstring graft led to a larger laxity, 2.4 mm compared with patellar tendon graft at 1 year and 2.5 mm at 2 years (p=0.05).³² Also 50% patient had + (glide) and 20% had ++ (clunk) pivot shift test at 1 year and 44.5% had + and 24% had ++ at 2 years follow up. Chadwick in his study showed average KT-1000 side-to-side difference and knee laxity was less in 5 strand hamstring group as compared to 4 strand group (p=0.01).³³ 5 strand hamstring tendon ACL reconstruction had higher stability than a high stability 4 strand hamstring tendon (Table 1).

Table 2: Showing results of other study and its comparison with our study.

Study	Sample size	Anterior Drawer test	Lachman test	Pivot shift test	Lysholm score	IKDC score	IKDC grade
Drogset et al ²⁴	57		Grade 2- 3 pts	Grade 1- 5 pts	91±10.3(12-100)		
Sajovic et al ⁴⁰	28		5 pts grade 1 and 1 pt grade 2	4 pts grade 1 and 1 pt grade 2	92 (62-100)		A-14; B-13; C-1
Laxdal et al ⁴¹	78		Grade 1- 27 pts; grade2- 2 pts		90 (41-100)		A-15; B-27; C-29;D-7
Ahlden et al ⁴²	25		Grade 1- 6 pts; Grade 2- 15 pts; Grrade 3 - 2 pts		89 (15-100)		
Our study	78 (six fold group)	1 (1.28%)	3 (3.84%)	2 (2.56%)	88.17±4.43	87.53±2.90	A-70; B-08
	35 (four fold group)	20 pts	13 pts	10 pts	74.29±6.17	74.83±4.62	A-3; B-31; C-1

Thus when compared to stability of knee in terms of anterior drawer test, Lachman test and pivot shift test 6 fold group patients showed statistically significant better outcome as compared to 4 fold group ($p < 0.05$) because of more thickness of graft and cross sectional area of six fold graft, but when compared to pre and postoperative knee stability in either group there was significant improvement in postoperative knee stability in both the groups.

The mean diameter of 6-strand hamstring tendons in this study is 9.73 mm, which is much thicker than 8 mm of 4-strand hamstring tendon.³⁴ The ultimate failure load of 8 mm four-fold hamstring tendon graft is about 4,090 N, which is more than for a 10-mm patellar tendon graft (2,977 N) and an intact ACL (2,160 N).³⁵⁻³⁷ Thus, reflecting ultimate load to failure of the 6-fold hamstring graft should be higher corresponding to the cross-sectional area.

Healing of the tendon to bone is more difficult to achieve and requires more time (usually eight to twelve weeks) than bone to bone healing (usually four to six weeks).^{38,39} Therefore, in this study, the authors increased the tendon-bone tunnel interface with the larger diameter graft in six fold group as compared to 4-fold group.

CONCLUSION

Arthroscopic ACL reconstruction using six fold graft is effective modality of treatment in patient with ACL deficient knee. Six fold graft is thicker in diameter and cross sectional area as compared to four fold graft which occupies more surface area of normal ACL foot print and gives better stability of knee joint in both AP and rotational plane. It gives better functional outcome as compared to four fold graft with good improvement in

knee ROM, pain relief in terms of VAS, knee stability, IKDC score, Lysholm score and with less complication and graft site failure rate. Patients treated with six fold graft had early return to preinjury level as compared to four fold group. The present results show that increasing cross-sectional area of hamstring tendons by using 6-strand graft can improve knee stability and reflected by the patient's activity in the early clinical outcome.

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Ethical approval: The study was approved by the institutional ethics committee

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