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Original Research Article

Arthroscopic anterior cruciate ligament reconstruction using single bundle hamstring tendon autograft

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ABSTRACT

Background: The present study was designed to analyze the postoperative outcome of arthroscopic anterior cruciate ligament (ACL) reconstruction with anatomical single bundle hamstring tendons autograft fixed in femoral tunnel using endobutton and in the tibial tunnel using interference screws and reinforced by anterior half of peroneus longus tendon (AHPLT), wherever required.
Methods: 39 patients of complete ACL tear underwent arthroscopic anatomical single bundle ACL reconstruction using quadrupled hamstring tendon autograft. It was ensured that the quadrupled graft had a length of at least 7 cm and thickness of at least 8 mm. If either of these requirements were not met, then the graft was supplemented by AHPLT. For functional assessment, international knee documentation committee (IKDC) knee score was taken and clinical tests for antero-posterior stability were done. In addition, the foot and ankle disability index (FADI) scores were used to evaluate the ankle donor site of the AHPLT.
Results: The average graft diameter was 8.74 mm and average graft length was 9.12 cm. There was significant improvement in post op IKDC score when compared with pre op score. There was no antero-posterior instability seen in any of the patients during follow up. 10 patients required an additional graft augmentation with AHPLT. There was no complaint about weakness of the ankle joint after surgery.
Conclusions: Arthroscopic ACL reconstruction with anatomical single bundle hamstring tendon autograft is an excellent treatment option for ACL deficient knees. It gives excellent functional outcome with minimal complications. Graft if small in diameter can be reinforced by AHPLT without any detrimental effect on ankle function.

INTRODUCTION

ACL is a major stabilizer of knee. The ACL is the primary stabilizer against anterior translation of the tibia on the femur and is very important in counteracting rotation and valgus stress.[1] Injury to ACL is most commonly linked with valgus, external rotation, hyperextension, deceleration and rotational knee movements. ACL rupture commonly results from non-contact, rotational or deceleration mechanism. Patient will usually report an audible pop followed by pain, swelling and inability to continue further activity. ACL rupture can also occur with combined multi ligamentous injuries as in dislocated knee.[2] An ACL-deficient knee predisposes to meniscal and cartilage tears, increasing the risk of early onset osteoarthritis.[3,4]

The goals of the ACL reconstruction are to re-establish stability to the knee, permit the patient to return to normal activities, including sports and to defer the beginning of osteoarthritis with associated recurrent injuries to the articular cartilage and loss of meniscal functions.[5-7]

Arthroscopically assisted ACL reconstruction has the upside of being minimally invasive, accurate graft placement, less disturbance of normal tissue bringing about faster recuperation and recovery, minimal hospital stay and very less infection rate.

Numerous authors have described successful reconstruction of the ACL with utilization of a donor autograft (patellar tendon, hamstring tendon or quadriceps tendon) and allograft (Achilles, patellar tendon, hamstring tendon or tibialis anterior) tendons. Anterior cruciate both bone-patellar-tendon-bone (BPTB) and hamstring tendon (HT) graft are commonly used. Despite highly successful, BPTB autograft has been associated with donor site morbidity, patellar fracture, anterior knee pain, kneeling pain and extension loss.[8,9]

On the other hand, ACL reconstruction using HT autograft has showed less surgical site complications, high tensile load, smaller incision for graft harvest, less perioperative pain, less anterior knee pain and high maximum load to failure.[10,11]

In recent years, various studies have elucidated the functional anatomy and biomechanics of the ACL. As a result, double-bundle (DB) ACL reconstruction has gotten a lot of consideration and has become a popular choice, which some studies professes to have better rotational stability and pivot resistance than the single-bundle (SB) method.[12,13]

Insall et al reported that the average length of a normal ACL is 38 mm (range 25-41 mm) with an average width of 10 mm (range 7-12 mm).[14] They state that hamstring grafts have been found to be considerably shorter in length and diameter in females as compared to male patients. They needed an additional source of graft for exceptional conditions that hamstring tendon's thickness is less than 7 mm because of technical errors of removing tendons or perhaps because of normal variations within the diameters of hamstring tendons. In 2012, Jinzhong Zhao did a study about biomechanical features, application of anterior half of peroneus longus tendon and its safety, adequacy and effectiveness. Author's conclusion was that it is a good autograft by advantages in bearing force, safety and risk. Biomechanical evaluations of the properties of complete peroneus-longus-tendon (PLT) grafts have been done recently and revealed that both the strength and stiffness of complete PLT grafts are suitable for knee ACL reconstruction. In addition, this graft is easy to harvest with minimal complications of the donor site in short and mid-term reports.[14] However, the PLT is an important stabilizing structure of the foot and ankle. If all of the PLT is removed as a graft, complications might occur in the long haul. Therefore, we just harvested anterior half of the PLT for reinforcing the inadequate hamstring tendon graft, and the other half was left in place to maintain its function in the current study. This half-PLT graft was used as a salvaging additional graft to reinforce unqualified hamstring tendon grafts for ACL reconstruction.

There has been the lack of an established consensus on the success of single-bundle reconstruction and also, on the efficacy of the split half of the peroneal tendon as reinforcement to HT tendon graft. The present study is designed to analyze the postoperative outcome of arthroscopic ACL reconstruction with anatomical single bundle hamstring tendons autograft fixed in femoral tunnel using endobutton and in the tibial tunnel using interference screws and reinforced by AHPLT, wherever required.

METHODS

After obtaining approval from the institutional research board and informed patient consent, this study was conducted in the department of orthopaedics at a tertiary care hospital in south Rajasthan from January 2019 to June 2020, on a sample size of 39 patients. Patients 18 years of age and above with ACL tear, as confirmed by clinical tests and MRI, were included in this study. Patients with fresh bony ACL avulsion injury, ACL tear associated with any fractures around the knee, revision ACL surgeries, previous knee surgeries, patients of ACL tear suffering from other significant internal derangements of knee except meniscal tears and patients with associated neuro-muscular disorders were excluded. A detailed history was taken, systemic examination was also done and along with routine blood investigations, X-ray knee and MRI scan of knee was done. A detailed physical examination of knee in general and specifically for ACL tear was done including Lachman test, anterior drawer test, and classic pivot shift test.

Diagnostic arthroscopy was performed and any chondral or meniscal procedures are performed at this time. For harvesting of hamstring graft, a 3-4 cm incision antero-medially on the tibia starting approximately 4 cm distal to the joint line and 3 cm medial to the tibial tuberosity was made. Pes anserinus insertion with subcutaneous dissection was exposed. The upper and lower borders of the gracilis and semitendinosus tendons were palpated 2 cm medial to the tendinous insertion. The more proximal of the two tendons is the gracilis and underneath it is the more horizontal and thicker semitendinosus tendon. They were then individually released from their tibial insertion site. This graft was then prepared on the ACL graft master (Figure 1). It was ensured that the quadrupled graft had a length of at least 7 cm and thickness of at least 8 mm; since studies shows that graft of less than 8 mm is prone to fail.[24] If either of these requirements were not met, then the graft was supplemented by anterior half of Peroneus Longus tendon. If required, the procedure for half-PLT graft harvesting was performed by making a 2 cm skin incision over the posterior border of the lateral malleolus. A tendon stripper was used to harvest the half tendon from the muscular part of the peroneus longus. Half of the PLT was removed as a salvaging tendon graft,

and the other half was left in place to maintain its original function (Figure 2). The harvested half-PLT was added to the unqualified hamstring tendon graft for reinforcement.

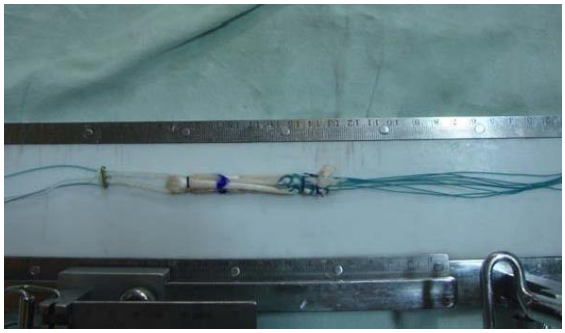

Figure 1: Prepared quadrupled graft with endobutton.

Figure 2: Harvesting of AHPLT.

For preparing the femoral tunnel, any ACL remnant was removed using a shaver while noting the anatomical footprint on the femoral and tibial side for later reconstruction. A small portion of the footprint was left intact to permit proper identification of the ACL origin and insertion. The center of the femoral footprint was marked with a femoral offset with the knee flexed to 90°. This anatomical footprint was used as a guide for making the femoral tunnel. The femoral offset ensures that there is at least 2 mm bony margin between the tunnel wall and the proximal and posterior articular margins. We have used inside-out technique for femoral tunnel drilling. With knee in hyperflexion (>120°), a guide pin is placed through the femoral offset into the previously marked femoral tunnel center. The pin was then advanced through the lateral femoral condyle and out the lateral aspect of thigh. With the knee held is hyperflexion, a 4.5 mm cannulated drill was used to drill over the guide pin and through the lateral cortex. The drill and guide pin are then removed, and the femoral tunnel was measured with a depth guide. The pin was then reinserted through the tunnel, which was then over reamed using an appropriate diameter drill (accordingly to graft thickness) and planned depth (accordingly to the graft length). Drilling was done at least 6 mm further then the planned graft depth to allow room to flip the endobutton.

Tibial tunnel was made through the previous vertical incision made for the hamstring graft harvesting. The tibial guide was set at 55° and placed at the ACL tibial footprint in line with the medial tibial spine roughly at the posterior aspect of the anterior horn of the lateral meniscus and approximately 15 mm anterior to the PCL. The external portion of the guide was seated flushed to the anteromedial tibia at about 1.5 cm medial to the tibial tuberosity and about 1 cm proximally to the pes anserinus. Next a 2.4 mm tibial guide pin was then advanced through the guide until the tip is visible protruding through the tibial footprint. Then a cannulated reamer of the appropriate diameter (accordingly to graft thickness) was advanced over the guide pin.

The graft was then passed through these tunnels and fixed on the femoral side using endobutton and on tibial side by metal or biointerferance screw of appropriate length and thickness. After wound closure, compression bandage dressing was done and long knee extension brace applied.

Patient was allowed knee mobilization exercises the same evening after surgery and was allowed to ambulate with knee brace. Full weight bearing with support was allowed as soon as the patients were comfortable and then discharged. The usual clinical follow-up included review at 10-14 days for wound inspection and suture removal and the brace was removed at 6 weeks. All the patients were put on postoperative ACL rehabilitation protocol on postoperative day 1. For functional assessment, patients were followed up after 6 weeks, 3 months and 6 months and IKDC knee score was taken and clinical tests for antero-posterior stability were done.[15] In addition, FADI scores were used to evaluate the ankle donor site of the half-PLT.[16] The FADI is designed to assess functional limitations related to foot and ankle conditions, and a maximum FADI score of 136 means normal ankle function without any disability.

RESULTS

39 Patients of complete ACL tear were admitted in our institute form January 2019 to May 2020. All the patients were included in this study. The mean age in our study was 31 years, the youngest patient being 19 years and the oldest patient 62 years old. The maximum number of patients were in the age group of 21-25 years (28.21%) followed by the age group 26-30 years (23.08%). In our series of 39 patients, 36 patients (92.31%) were males and 3 patients (7.69%) were female. It may be because of the involvement of males in outdoor activities like sports, farming and road traffic accidents. Right knee was injured in 23 patients (59%) and left knee was injured in 16 patients (41%). Most of the ACL tears were caused by road traffic accidents (46%). Next common cause was sports activities like football, kabbaddi and athletics like jumping, police physical training, etc. Some patients (23%) got injured by slips and fall while doing daily activities or while walking/ climbing down stairs. All

patients presented with complaints of giving way of the knee.

Table 1: Demographic data (n=39).

Characteristics		N (%) or mean (range)
Age distribution (years)		31 (19-62)
Sex distribution	Male	36 (92.13)
	Female	03 (7.69)
Side of injury	Right	23 (59)
	Left	16 (41)
Nature of injury	RTA	18 (46)
	Sports injury	12 (31)
	Fall	9 (23)
Associated injuries on MRI	MM	14 (35.90)
	LM	09 (23.08)
	MCL	02 (5.13)
	LCL	03 (7.69)
	PCL	03 (7.69)

Table 2: Graft parameters (n=39).

Parameters	Mean or N
Graft diameter	8.74 mm (8-10 mm)
Graft length	9.12 cm (8.5-11 cm)
Augmented with AHPLT	10 (25.64%)

The mean graft diameter (thickness) in our study was 8.74 mm (range 8 to 10 mm) including those grafts which were augmented with AHPLT. The mean graft length in our study was 9.12 cm (range 8.5 to 11 cm) after quadrupling as shown in Table 2.

Total 10 patients (25.64%) in our study had <8 mm of graft diameter so they required an additional graft augmentation with AHPLT. Ankle stability of these patients was assessed at 6 months of follow up. All the patients had near normal FADI score at the end of 6 months with a mean of 135.7 (range 135-136).

In our study none of the patients had any clinical instability as checked by tests such as anterior drawers test, Lachman's test and pivot shift test at 6 weeks, 3 months and 6 months of follow up. The mean pre-op IKDC subjective score was 47.77 while the mean post op score (at 6 months) was 87.90. There was significant improvement in post op IKDC score when compared with pre op score ($p<0.05$) as shown in Table 3.

Early superficial infection of the graft site was present in only 1 case (2.56%) which delayed wound healing. There was no deep infection. It was resolved by local wound care and oral antibiotics. No other complications were seen in any of the patients.

Table 3: Comparison of pre and post-operative result.

	Pre op mean (standard deviation)	Post op mean (standard deviation)	P value
IKDC Subjective Score	47.77 (9.99)	87.90 (6.30)	0.00001

DISCUSSION

Due to the increased occurrence of road traffic accidents and increased number of persons participating in sports activities, the number of ACL reconstructions being done has been increased.

ACL ruptures if left untreated, lead to subsequent knee disability, which can be severe with potentially decimating long term consequences. With improving results and increasingly reliable outcomes, patient and physician expectations have evolved to include the goal of return to activities and sports at normal or near normal levels. Arthroscopic reconstruction of the injured ACL has become the gold standard.[17]

The choice of graft has been a topic of great debate in recent years. The various options include bone patellar tendon bone graft, hamstring auto-graft, quadriceps tendon, various synthetic grafts and allograft out of which hamstring autografts have over the past decade increasingly become more popular. Several studies have shown that using multiple-strand hamstring tendon autograft for ACL reconstructions have higher strength, stiffness and cross-sectional area compared with patellar tendon grafts.[12]

The advantages of arthroscopic ACL reconstruction using hamstring graft include decreased surgical site morbidity, decreased occurrence of patellofemoral adhesions and reduced incidence of anterior knee pain. Though the semitendinosus tendon has only 75% and gracilis 49% of the strength of native ACL, the quadrupled semitendinosus or semitendinosus-gracilis have a tensile load of around 4108 N. Harvest of hamstring tendon autografts also yields less donor site morbidity than harvest of patellar bone-tendon-bone grafts and carries no risk of patellar fracture, however remote.[10,11]

In our prospective study, there was male predominance (36 male and 3 female). This may be due to the fact that males are more involved in outdoor activities like sports,

farming and road traffic accidents. Most of the patients were in the age group of 21 to 25 years (28.21%) with a mean age of 31 years. In our study, 59% patients (n=23) had a right sided tear while 41% (n=16) had left sided. In 2009, Brown and others studied the incidence of sex and limb differences in anterior cruciate ligament injury and stated that even though females are prone for injury, due their less exposure to strainous environment makes the incidence of males more than females.[18] They also concluded that limb differences have no influence either during injury or in the recovery period.

DW Lewis et al in their study on incidence of meniscal injuries at the time of ACL reconstruction found that 58% of patients had meniscal injuries and that medial meniscus was most commonly injured.[19] They also concluded that meniscal repair or resection did not alter the final outcome. In our study 59% patient had an associated meniscal injury, of which medical meniscus (n=14) was more frequently involved then lateral meniscus (n=9) which is in accordance with other studies. Among these patients 8 were treated with partial meniscectomy and rest were treated conservatively. The functional outcome of patients with isolated ACL injury was comparable with that of the patients with associated meniscal injuries. This is in accordance with the study by DW Lewis et al who stated that the presence of meniscal injury does not alter the functional outcome.

The mean pre-operative IKDC score in our study was 47.77 whereas the post-operative score was 87.90. There was significant improvement in post-operative IKDC score when compared with pre-operative score ($p<0.005$). The final IKDC score of this study were compared with the studies of Ashok Kumar et al 2016, Prasad et al 2017 and Aparajit et al 2016.[20-22] The mean pre-operative IKDC score in the study by Kumar et al was 55.63, Prasad et al was 42.45 and Aparajit et al was 50.5 whereas the post-operative scores were 89.38, 94.33 and 86.03 respectively. In our study, none of the patients had any antero-posterior instability at any of the follow up visits, as assessed by clinical tests such as anterior drawers, Lachman's and pivot shift.

There was no significant patellofemoral pain noticed in the patients in our study. This is similar to the study by Railey et al who did not observe any clinically relevant patellofemoral pain in patients in whom arthroscopic ACL reconstruction using hamstring graft was done.[23] While none of the studies where hamstring graft was used showed significant patellofemoral pain, the studies in which bone-patellar tendon-bone graft was used showed significant anterior knee pain.

In our study 10 patients (3 female and 7 male) had a graft thickness (diameter) <8 mm so they required an additional graft augmentation with AHPLT along with the hamstring tendon. All of the three female patients in our study required augmentation with AHPLT. Female patients have statistically significantly shorter length and smaller diameter hamstring grafts compared with male patients. The IKDC score of these half-PLT salvaged patients were similar with patients undergoing traditional ACL reconstruction by hamstring graft. AHPLT is an effective method to reinforce the unqualified hamstring graft. The harvesting of AHPLT had no significant effect on ankle function post operatively as seen by the insignificant difference of FADI between the preoperative and postoperative values in these patients. Kerimoğlu et al evaluated the results of ACL reconstruction with complete peroneous longus tendon grafts.[24] The results were assessed after at least 5 years of follow-up and showed a mean Lysholm score of 83.7, with excellent or good results in 79.3% of the patients. In addition, no patients experienced ankle joint donor site dysfunction or difficulty in sports activities because of the complete PLT graft transfer. Another short term study of ACL reconstruction with a complete PLT graft also showed encouraging results and no donor site complications.[25]

The mean graft diameter (thickness) in our study was 8.74 mm (range 8 to 10 mm) including those grafts which were augmented with AHPLT. The mean graft length in our study was 9.12 cm (range 8.5 to 11 cm). Various other studies have demonstrated that the average diameter of the graft to be 10 mm (range 7-12 mm) and average length of 9.3 cm (range 9 to 11 cm).[26-28] These studies have recommended minimum graft thickness of 7 mm. The thicker the graft, stronger and stiffer the graft will be.

Early superficial infection of the graft site was present in only 1 patient (2.56%) in our study which delayed wound healing. There was no deep infection. It was resolved by local wound care and oral antibiotics. No other complications were seen in any of the patients. Williams et at in their study of 2500 cases of arthroscopic ACL reconstruction, reported an infection rate of 0.3%.[23]

Several limitations should be taken in account firstly, small sample size (n<100). Overestimation of treatment effect is more likely in small sample size compared to large sample size. Another limitation may be that the follow up time in the included study is up to 6 months due to time limitations; a longer follow up time is needed to evaluate some long term complications and graft strength. Our study was not a comparative one; we have exclusively used anatomical single bundle hamstring graft for reconstruction of ACL. Other graft option which can be closely compared with this study is double bundle hamstring graft. The difference in efficacy and strength between them needs to be evaluated. Further research is necessary, in order to evaluate which of this surgical technique in long term provides us with the safe and effective management options for ACL reconstruction.

CONCLUSION

Arthroscopic anterior cruciate ligament reconstruction with anatomical single bundle hamstring tendon autograft

seems to be a good treatment option for anterior cruciate ligament deficient knees. It gives excellent functional outcome with minimal complications. Graft if small in diameter can be reinforced by anterior half of peroneus longus tendon without any detrimental effect on ankle function.

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