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Transportal single bundle ACL reconstruction with quadruple hamstring graft using suspensory femoral and hybrid tibial fixation: A prospective study

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Abstract
Objectives: The aim of the study was to evaluate the functional outcome of transportal single bundle ACL reconstruction with Quadruple Hamstring Graft using suspensory femoral and hybrid tibial fixation for restoration of joint stability, patient satisfaction and for any complications.
Design: Prospective Study Design.
Methods: Patients admitted to the department of Orthopaedics, Bhagat Phool Singh Government medical college, Khanpur Kalan, Sonipat and fulfilling the inclusion criteria of age group 20-45 years without pre-existing arthritis and clinical and radiological evidence of anterior cruciate ligament tear were included in the study who were followed upto six months. Preoperatively Lysholm score and IKDC score was evaluated of each patient and post operatively Lysholm score and IKDC score were calculated at 2 weeks, 8 weeks, 12 weeks and 24 weeks.
Results and conclusion: All patients were taken for single bundle ACL reconstruction using suspensory femoral and hybrid tibial fixation. The Lysholm and Knee Scoring Scale consists of eight parameters for evaluation. The individual parameters were allotted specific scores depending on the patient's functional ability. The maximum possible knee score was 100. Based on the outcome scores they were divided into Excellent, Good, Fair and Poor. The Subjective IKDC scale was evaluated by summing the scores for the individual items and then transforming the score to a scale that ranges from 0 to 100. The patients were followed up in OPD and their functional outcomes were measured by Lysholm scoring and IKDC scoring at 2 weeks, 8 weeks, 12 weeks, 24 weeks. There were 20 (83.3%) male patients and 4 (16.7%) female patients. The right side was more commonly injured (54.2%) than the left side (45.8%). The most common mode of injury in our study was Road Traffic Accidents (58.3%) followed by sports (20.8%). Most of the patients (41.7%) presented 4 to 6 months after injury. The most common symptom at presentation was knee pain (37.5%) followed by instability (29.2%). Both knee pain and instability were present in 16.7% of patients. There was associated meniscal injury in 75.0% of patients. The most commonly injured was medial meniscus (50%) followed by injury to both medial and lateral menisci (16.7%). Isolated ACL tear was present in 25% of the patients. In our study, 83.3% had excellent functional outcome while 16.7% patients had good outcome on the basis of Lysholm Scoring. In our study the mean pre-operative IKDC score was 55.60 whereas the post-operative score after 24 weeks was 86.13. There was significant improvement in post-operative IKDC score when compared with preoperative score.
In young active adults, anatomic single bundle reconstruction with quadrupled hamstring graft gives good functional results. Endobutton on the femoral side and Bioabsorbable interference screw and suture disc on the tibial end is a good mechanical and strong suspensory type of fixation device for ACL reconstruction. This technique offers an excellent knee function, knee stability and restoration of preoperative functional status with minimal complication. The patients undergoing hybrid method of fixation return to preinjury level of activity early.

Keywords: ACL, Hamstring graft, hybrid tibial

Introduction
Anterior Cruciate Ligament (ACL) tear is one of the most common traumatic injuries of the knee. The exact incidence of ACL injury is unknown, but it is estimated that 1 out of 3,000 persons develops ACL tear annually which leads to 100,000 ACL reconstruction surgeries [1]. Reconstruction of the anterior cruciate ligament (ACL) is the most successful procedure available in restoring knee stability and function after ligament rupture [2].

Today, ACL reconstruction using autologous grafts from the tendons of the gracilis and semi-tendinosus muscles has gained popularity because of the lower morbidity at the graft donor site, lower incidence of femoropatellar symptoms and lower incidence of contractures in flexion [3, 4].

Recent studies have shown that when the femoral tunnel is positioned more anatomically in relation to the femoral insertion of the ACL, it provides better rotational control of the knee, better knee mobility and less chance of impact of the ACL on the Posterior Cruciate Ligament (PCL) during flexion [5].

There are three techniques for constructing the femoral tunnel: the transtibial technique, the outside-to-inside or two-incision technique and the trans-portal technique (anteromedial or accessory medial portal). Some studies have shown that with the transtibial technique, in which the femoral tunnel is constructed through the tibial tunnel, it is more difficult to achieve anatomical positioning of the femoral tunnel [6, 7]. For this reason, the anteromedial transportal technique, with tunnels constructed independently and without the need for an additional incision in the lateral face of the femur, is a constant focus of discussion.

Fixation methods may be roughly divided into aperture (intratunnel) and suspensory (extratunnel) fixation, depending on the placement and type of the fixation device. Aperture fixation fixes the graft closer to the joint line, decreasing working length and thereby increasing stiffness of the construct. However, this method relies on adequate metaphyseal bone stock for interference fixation. Suspensory fixation theoretically provides more secure fixation via attachment to dense metaphyseal cortical bone but also increases working length, and permits sagittal and longitudinal micromotion, which may interfere with osseous integration of the graft.

Some studies have recommended the use of hybrid fixation (combining intratunnel aperture fixation and extracortical suspensory fixation) on the tibial side to increase the strength of the reconstructed ACL and decrease the risk of graft slippage and subsequent failure. However, no consensus has emerged on the necessity or suitability of this technique, relative to single modes of fixation [9].

By combining aperture fixation, which shortens the working length of the graft and increases stiffness, with suspensory fixation on denser cortical bone, surgeons may potentially create a load-sharing construct that is better able to resist the stresses of early active rehabilitation protocols. Such techniques, however, come with the risk of additional complications (especially anterior tibial tenderness or skin irritation) and added cost. As such, some authors have suggested reserving hybrid techniques for cases where the quality aperture fixation is perceived to be insufficient. The addition of supplementary cortical fixation to aperture fixation may improve objective stability after healing [9].

Pullout strength at metaphyseal bone in tibia has been reported less than that in femur from many biomechanical studies. The reasons are that the bony structure of the tibial metaphysis is less dense than that of the femoral metaphysis and that the direction of pullout force of the graft is parallel to the tibial tunnel, while it is usually angled to the femoral tunnel. The softer cancellous bone in the tibia impairs the grip of fixation devices that primarily engage cancellous bone, such as the interference screw. Poor fixation may increase the chance of residual laxity and often lead to unsatisfactory outcomes of operation. Sufficient stiffness of graft fixation allows early mobilization and lessens the residual laxity. In tibial tunnel, soft tissue grafts are usually fixed with interference screw and staple or spiked washer screw is often used for supplementary fixation on tibial cortex to improve stiffness of the graft construct. These additional fixations often cause problems due to considerable profile at fixation site and irritation of soft tissue coverage especially with spiked washer screw or staple [10].

Thus, there is no clear biomechanical advantage to one method of fixation versus another. It is also unknown whether these biomechanical differences result in fewer surgical failures and/or improved functional outcome scores. Strong fixation of the graft is necessary for using current rehabilitation protocols, which allow for early weight bearing, full ROM, and return of neuromuscular function. Low harvest morbidity and excellent biomechanical graft properties coupled with improved fixation of soft tissue grafts are all reasons for excellent clinical outcomes of ACL reconstruction using hamstring tendons [11]. Suspensory methods using endobutton for femur and suture disc for tibia tunnel fixation and aperture methods of fixation have been described, with aperture fixation resulting in increased stiffness of the construction compared with the suspensory method [12, 13]. Many studies have demonstrated that hamstring grafts have fewer problems with anterior knee pain, quadriceps muscle deficits, loss of extension compared with BPTB autografts [14].

The choice of fixation in ACL reconstruction is still evolving and the current fixation device which has been widely used were the endo button and the Bioabsorbable interference screws which has helped to render an improved rehabilitation program post operatively [15]. Graft choice, surgeon experience, correct graft position, choice of graft fixation and postoperative rehabilitation confound the results of comparison of ACL reconstruction [16].

The purpose of our study was to assess the functional outcome of transportal single bundle ACL reconstruction with quadruple hamstring graft using suspensory femoral and hybrid tibial fixation. Also, there has been paucity of both literature and data regarding this topic.

Materials and Method

Sample size

The study was conducted in 24 patients. The sample size was calculated based on previous studies by Jarvela *et al*. [25] and Streich *et al*. [26]. Calculations were done using Master 2.0 software.

The standard deviation 12 of mean was taken as 14. Absolute precision was taken as 4 with the power of study being 90% and alpha error at 5%, with confidence interval 95% the sample size was calculated to be 24 patients.

Study procedure

Patients admitted to the department of Orthopaedics, Bhagat Phool Singh Government medical college, Khanpur Kalan, Sonipat with ACL injuries who were followed upto six months were included in the study.

- Patients fulfilling the inclusion criteria and giving informed consent were taken for participation in the proposed study.
- Preoperatively patients were assessed using Lachman test, Anterior Drawer Test appropriate
- X-ray and MRI was done to evaluate for the ACL injury.
- Preoperatively Lysholm score and IKDC score was evaluated of each patient.
- Standard surgical procedures, anesthesia techniques, tourniquet and rehabilitation protocols were followed.

- Post operatively Lysholm score and IKDC score were calculated at 2 weeks, 8 weeks, 12 weeks and 24 weeks. Inclusion and Exclusion criteria

The inclusion and exclusion criteria were as follows:

Inclusion criteria:

1. Patients in the age group 20-45 years without pre-existing arthritis.
2. Patients with clinical and radiological evidence of anterior cruciate ligament tear.

Exclusion criteria:

1. ACL rupture and Posterior cruciate ligament rupture/postero-lateral corner insufficiency/ medial collateral ligament insufficiency
2. Bilateral ACL tear
3. Revision ACL reconstruction

Surgical procedure

The subject was positioned in the supine position on the operation table

- Lachmann and pivot shift test were performed with the patient under anaesthesia
- A tourniquet was placed high on the thigh.
- A distal support placed on the table kept the knee flexed at an angle 90 degree.
- Anterolateral and anteromedial portal were made in the standard manner.
- Diagnostic arthroscopy performed.
- The semitendinosus and gracilis tendons harvested with a tendon stripper through a 3- 4 cm vertical incision 2 fingerbreadths medial to tibial tuberosity. Graft preparation and configuration done on graft preparation table.
- Removal of excess muscular tissue from each tendon graft performed and unstable portion of tendon removed. Measurements of length of each harvested tendon done.
- The free ends of the graph whipstiched together with a nonabsorbable suture (number 5 ethibond) A non-absorbable suture passed in the middle, and tendons were folded.
- Appropriate graft length and diameter checked by tendon sizer.
- Graft is loaded in suspensory fixed loop length device (endobutton) usually 15 or 20 mm. An appropriate length from the folded and marked with an ink marker.
- Femoral tunnel preparation done through anteromedial port with knee in maximum flexion (1200) A guide wire advanced so that it exits through the femoral cortex.
- Femoral tunnel length to be reamed with 4.5 mm reamer through and through and measured with depth gauge. Using the appropriate diameter reamer, the femoral tunnel is reamed based on the respective graft size and last 5mm is not reamed. Number 2 ethibond attached to eye of guide wire passed through anteromedial port to the femoral tunnel exiting lateral aspect of thigh. Tibial guide wire placed at center of the ACL foot print, as a reference point by using tibial jig at 55-degree angle.

Guide wire passed and cannulated reamer over it as determined by the prepared graft diameter size. Using suture retriever through tibial tunnel, the outer end of ethibond pulled and secured to the already prepared pretensioned graft with endobutton attached, and pulled out of the femoral tunnel so that threads are out of the thigh.

Under arthroscopic visualization, the threads of endobutton pulled using the principle of flipping the endobutton and femoral fixation confirmed by togging of the endobutton. Tension placed on the graft, 15 to 20 cycles of complete knee flexion and extension performed. This helps to align the grafts and also tests for impingement between the grafts and bony structures.

Graft fixed with bioabsorbable interference screw, size of which is more than 1mm to the size of tibial tunnel and placed in tibial tunnel while applying tension. The tibial side of the graft fixed with suture disc and held over the tibial tunnel by passing the ethibond threads through the suture disc and tightening the knots around the disc. Graft harvest site sutured in layers with 2-0 vicryl.

- Skin sutured and compression bandage dressing done.
- Long knee extension brace applied for 3 weeks.
- 23 post-operative management Patient was given intravenous antibiotics for 5 days
- Post-operative knee elevation was done for 24 hours
- Quadriceps strengthening exercise was performed immediately after the surgery,
- Partial weight bearing was allowed on the third day and full weight bearing was allowed as tolerated. Continuous passive motion (CPM) exercise was begun on the second postoperative day, and it was allowed up to 90 degrees of flexion until the fourteenth day, 120 degrees until the sixth week, and full range of motion afterward. After 12 weeks, jogging and stationary bicycling were allowed.
- After 6 months, subjects were allowed to do competitive sports except for those exercises that might involve strong contacts with others such as football or soccer, or those exercises that might impose strong external forces on the subjects‟ knee such as skiing or snowboarding. All kinds of exercises were allowed after 9 months.

Statistical analysis

Descriptive statistics was performed by calculating mean and standard deviation for the continuous variables. Categorical variables are presented as absolute numbers and percentage. Nominal categorical data between the groups were compared using chi-square goodness-to-fit test. The software used for the statistical analysis were SPSS (statistical package for social sciences) version 21.0 and Epi-info version 3.0.

Paired or Dependent t-test was used for comparison of 2 mean values obtained from a same group or a pair of values obtained from the same sample when the data follows normal distribution.

The p-value was taken significant when less than 0.05 ($p<0.05$) and Confidence interval of 95% was taken.

Fig 1: MRI showing ACL injury

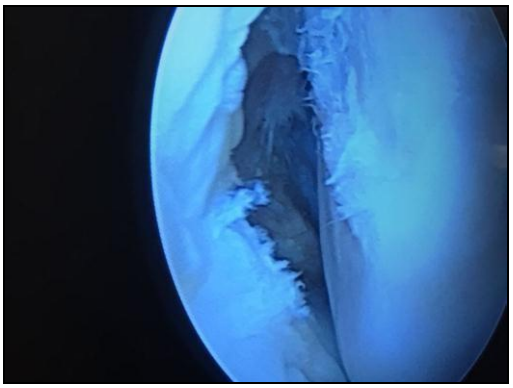

Fig 2: ACL tear

Fig 3: Femoral Tunnel

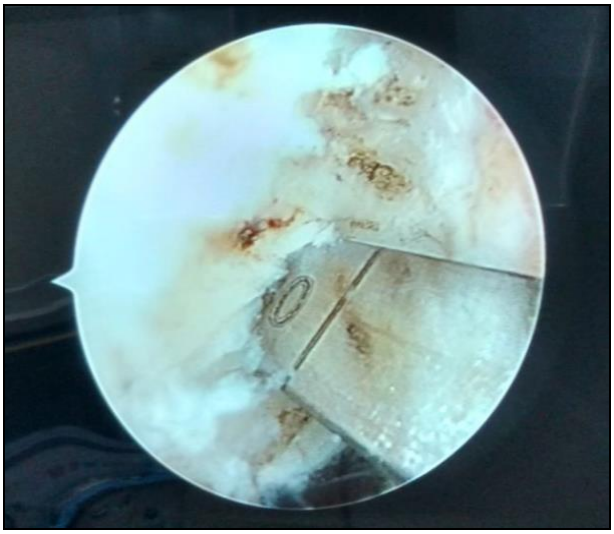

Fig 4: Measurement of Femoral using depth gauge

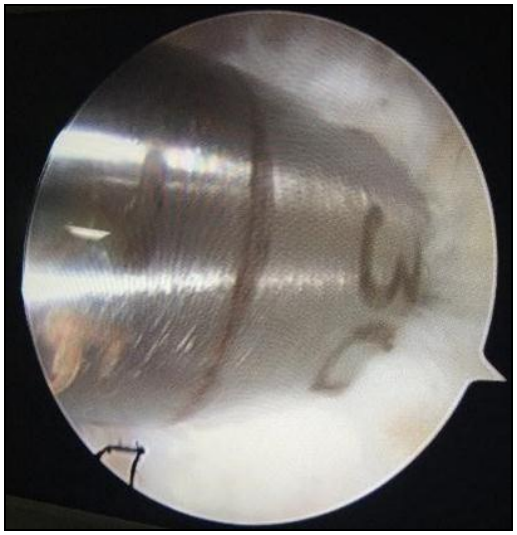

Fig 5: Showing preparation of tunnel femoral tunnel

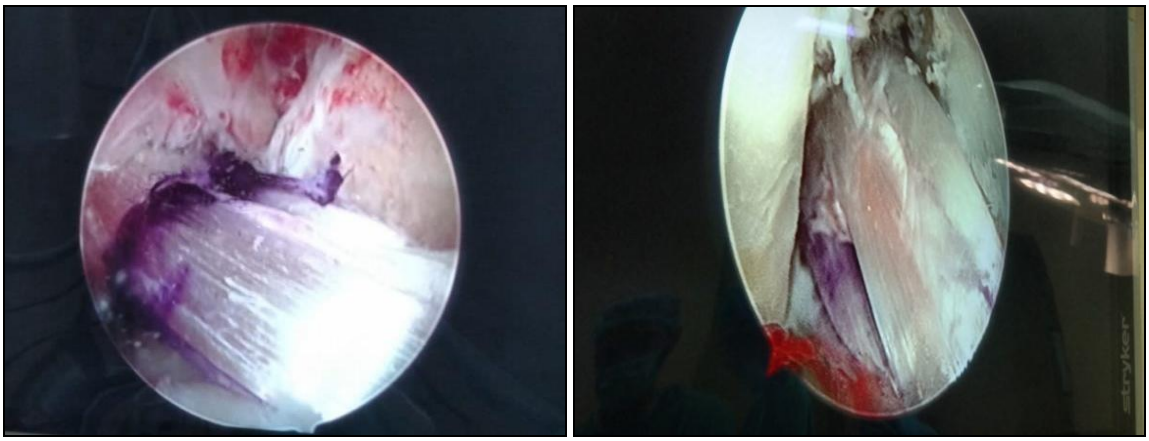

Fig 6: Showing graft placement

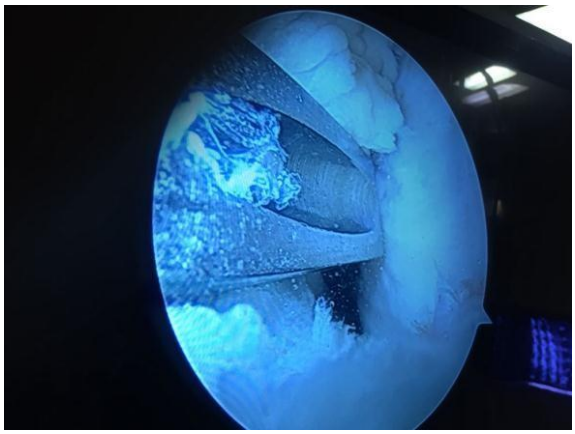

Fig 7: Showing preparation of femoral tunnel using offset

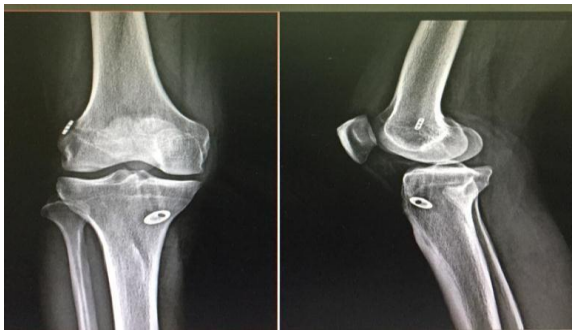

Fig 8: Post op xray

Results

This prospective study was conducted at the Department of Orthopaedics, Bhagat Phool Singh Government Medical College, Khanpur Kalan, Sonipat. We included 24 patients in the study after meeting the exclusion criteria. Their demographic and clinical data was analysed. The result of the study is as follows:

Table 1: Showing the age distribution of study population

Age (in years)	Number	Percentage
20-25 years	8	33.3%
26-30 years	5	20.8%
31-35 years	6	25.0%
36-45 years	5	20.8%
Total	24	100.0%

In our study, patients presented to orthopaedics department were stratified by age for analysis as shown in table 1. Maximum patients who had ACL tear were in the age group of 20-25 years (33.3%) followed by the age group of 30- 35 years (25%).

Table 2: Gender distribution of the study population

Gender	Number	Percentage
Male	20	83.3%
Female	4	16.7%
Total	24	100.0%

Table 3: Side involved in ACL tear

Side involvement	Number	Percentage
Right side	13	54.2%
Left side	11	45.8%
Total	24	100.0%

Table 4: Mode of injury

Mode of injury	Number	Percentage
Road traffic accidents	14	58.3%
Sports	5	20.8%
Others	5	20.8%
Total	24	100.0%

Table 5: Showing the distribution of study population according to duration between injury and surgery

Duration between injury and Surgery	Number	Percentage
Up to 3 months	7	29.2%
4-6 months	10	41.7%
7-9 months	3	12.5%
10-12 months	4	16.7%
Total	24	100.0%

Table 6: Showing the distribution of study population according to symptom at presentation

Symptom at presentation	Number	Percentage
Knee pain	9	37.5%
Instability	7	29.2%
Locking	4	16.7%
Knee pain and Instability	4	16.7%
Total	24	100.0%

Table 7: Showing the distribution of study population according to associated meniscal injuries

Associated injuries	Number	Percentage
Isolated ACL tear	6	25.0%
Medial meniscus tear	12	50.0%
Lateral meniscus tear	2	8.3%
Medial and lateral meniscus tear	4	16.7%
Total	24	100.0%

Functional Evaluation

Table 8: Showing Clinical result of physical examination of patients at 6 months follow up

Test	Pre-operative	At 6 month follow up	p-value
Anterior Drawer			
0	0	21	0.001
1	0	2	
2	19	1	
3	5	0	
Lachman test			
0	0	16	0.001
1	2	7	
2	19	1	
3	3	0	
Pivot-shift			
0	3	19	0.001
1	20	5	
2	1	0	
3	0	0	

Table 8 shows that there was improvement in the anterior drawer test, Lachman test and pivot shift test at 6 months follow up from grade 2 (n=19) or grade 3 (n=5) to grade 0(n=21) or grade 1(n=2) or grade 2(n=1), from grade 2 (n=19) or grade 3 (n=3) to grade 0(n=16) or grade 1(n=7) or grade 2(n=1), from grade 1 (n=20) or grade 2 (n=1) to grade 0(n=19) or grade 1(n=5) respectively.

IKDC score

Table 9: Showing the mean IKDC score

IKDC score	Mean±SD	F-value	p-value
Pre-op	55.60±3.63	28.082	0.001*
2 weeks	35.17±3.29		
8 weeks	65.87±4.10		
12 weeks	75.77±4.36		
24 weeks	86.13±4.46		

Table 10: Comparison of IKDC score with different time points

		Mean Difference	Std. Error	p-value	95% Confidence Interval for Difference	
					Lower Bound	Upper Bound
Pre-operative	2 weeks	20.43	0.24	0.001*	19.710	21.157
	8 weeks	-10.27	0.30	0.001*	-11.187	-9.346
	12 weeks	-20.17	0.40	0.001*	-21.395	-18.939
	24 weeks	-30.53	0.44	0.001*	-31.866	-29.200
2 weeks	8 weeks	-30.70	0.32	0.001*	-31.679	-29.721
	12 weeks	-40.60	0.39	0.001*	-41.771	-39.429
	24 weeks	-50.97	0.43	0.001*	-52.273	-49.660
8 weeks	12 weeks	-9.90	0.25	0.001*	-10.648	-9.152
	24 weeks	-20.27	0.28	0.001*	-21.115	-19.418
12 weeks	24 weeks	-10.37	0.15	0.001*	-10.815	-9.918

Post hoc analysis (Table 10, figure 24) showed that there was a significant mean difference in IKDC score among the various time points when compared individually. Further it was observed that when the mean difference of IKDC score was compared between pre-op and other time points there was a fall from pre-op to 2 weeks which increased gradually up to 24 weeks.

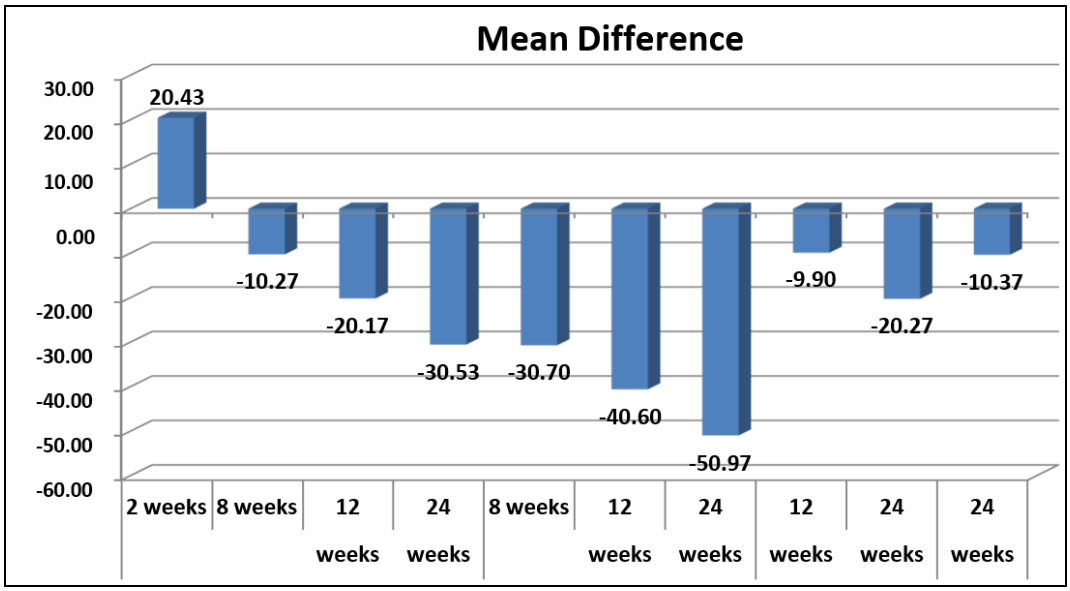

Fig 9: Comparison of IKDC score with different time points

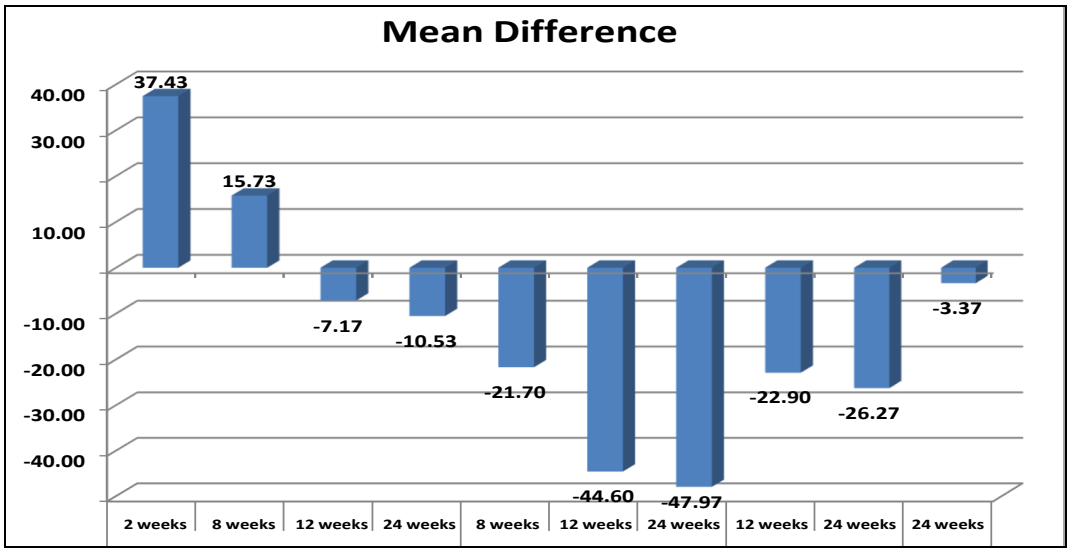

Fig 10: Comparison of Lysholm knee score with different time points

Table 11: Comparison of Lysholm knee score with different time points

		Mean Difference	Std. Error	p-value	95% Confidence Interval for Difference	
					Lower Bound	Upper Bound
Pre-operative	2 weeks	37.43	0.24	0.001*	36.710	38.157
	8 weeks	-15.73	0.30	0.001*	-14.813	-16.654
	12 weeks	-7.17	0.40	0.001*	-8.395	-5.939
	24 weeks	-10.53	0.44	0.001*	-11.866	-9.200
2 weeks	8 weeks	-21.70	0.32	0.001*	-22.679	-20.721
	12 weeks	-44.60	0.39	0.001*	-45.771	-43.429
	24 weeks	-47.97	0.43	0.001*	-49.273	-46.660
8 weeks	12 weeks	-22.90	0.25	0.001*	-23.648	-22.152
	24 weeks	-26.27	0.28	0.001*	-27.115	-25.418
12 weeks	24 weeks	-3.37	0.15	0.001*	-3.815	-2.918

Post hoc analysis showed that there was a significant mean difference in Lysholm score among the various time points when compared individually. Further it was observed that when the mean difference of Lysholm score was compared between pre-operative and other time points there was a fall from pre-operative to 2 weeks by 37.43. However, it increased by 15.73 at 8 weeks, 7.17 at 12 weeks and 10.53 at 24 weeks as shown in Table 12, figure 26.

Table 12: Showing the functional outcome according to Lysholm Knee score

Outcome as per Lysholm score	Number	Percentage
Excellent	20	83.3%
Good	4	16.7%
Fair	0	0.0%
Poor	0	0.0%
Total	24	100.0%

In our study, 20 (83.3%) patients had excellent functional outcome while 4 (6.7%) patients had good outcome according to Lysholm knee score.

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. Arthroscopic reconstruction of the injured ACL has become the gold standard and is one of the most common procedures done in orthopaedics and thus it has been extensively studied and outcomes of ACL reconstruction have gained considerable attention.

The choice of graft is a topic of great debate in recent years. The various options include bone patellar tendon bone graft, hamstring autograft, quadriceps tendon, various synthetic grafts and allograft. Among these, the most commonly used are the bone patellar tendon bone graft (BPTB) and hamstring graft. But the hamstring graft has been increasingly used in recent. 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 [23]. Chen *et al.*, reported that ACL reconstruction using a quadrupled hamstring autograft had little graft side morbidity, low reoperation rate and excellent clinical result [10].

Various fixation methods have been described for ACL reconstruction. They can be classified into aperture fixation and suspensory methods. The aperture fixation methods like the interference screws allows for early firm fixation and heal with tight bone-tendon interface. The suspensory methods can be sub-classified into cortical, cancellous and cortico-cancellous suspension methods. The cortical suspensory method provides excellent fixation strength, but it has been associated with bungee cord effect and a windshield wiper effect due to the far fixation point from the articular surface. The cortico-cancellous suspension method like the cross-pin fixation is said to have strong stability and stiffness due to its rigid fixation. Milano *et al.* in a study comparing the biomechanical strength of different femoral fixation devices for ACL reconstruction with quadrupled hamstring graft concluded that the cortical-cancellous suspension fixation seemed to offer the best and most predictable results in terms of elongation, fixation strength, and stiffness [8]. The choice of fixation in ACL reconstruction is still evolving and the current fixation device being widely used include endobutton and bioabsorbable interference screws which have helped to render an improved rehabilitation program post operatively [14].

The aim of our study was to evaluate the functional outcome of arthroscopic single bundle ACL reconstruction with quadrupled hamstring graft using suspensory femoral and hybrid tibial fixation.

This prospective study was conducted in Bhagat Phool Singh Government Medical College, Khanpur Kalan, Sonipat. In our study all patient underwent ACL reconstruction with single bundle quadruple hamstring graft using suspensory femoral

and hybrid tibial fixation.
24 patients were enrolled in the study after meeting the inclusion and exclusion criteria and their data was analysed.

Age wise comparison
In our study patients were included from 20-45 years of age. Average age of patients at the time of surgery in the present study was 29 years. Maximum patients (33.3%) were in the age group of 20-25 years where as in a study by Chidanand *et al*. mean age was 31.6 years and and maximum patients (30%) were in the age group of 31-35 years [14]. In another study by Jagtap [15] *et al.* maximum patients (30%) were in the age group of 21-25 years which was similar as seen in our study.

Gender wise comparison
Of the 24 patients included in our study, 20 (83.3%) were male patients and 4 (16.7%) were female patients. In the study by Chidanand [14] *et al.*, male patients accounted for 93.33% and females accounted for 6.67%. In another study conducted by Jagtap [15] *et al.*, male patients accounted more than female as seen in our study. Male preponderance may be related to their frequent involvement in outdoor work and strenuous activities. Males are more frequently involved in sports and RTA.

Mode of injury wise comparison
In our study, the most common mode of injury was Road Traffic Accident (RTA) followed by sports injuries. One of the patients had an injury due to kick by a bull. Among the sports injuries, Kabaddi was the most common cause of ACL tear. Whereas in a study conducted by Chidanand [14] *et al.*, most common mode of injury was found to be sports injuries followed by RTA. In a study by Prasad Aparajit [21] *et al.* RTA was the most common mode of injury as seen in our study.

Side of injury wise comparison
The right knee was involved in 13 (54.2%) of patients and left knee in 11 (45.8%) patients. There was not much difference in lateralization of injury. This was similar to the study by Chidanand *et al.*, where 16 out of 30 patients (53.33%) got right knee involvement and 14 had left knee ACL tear (46.67%).

Associated injuries
In our study, there was associated meniscal injury in 75% of patients. Six patients in our study had isolated ACL injury. Twelve patients had injury to the medial meniscus whereas two patient had injury to the lateral meniscus alone. Four patients had injury to both the medial and lateral meniscus. The most commonly injured was medial meniscus which was in accordance with other studies [14, 15]. We also concluded that meniscal repair or resection did not alter the final outcome.

Common symptom at presentation comparison
The most common symptom at presentation was knee pain (37.5%) followed by instability (29.2%). Both knee pain and instability were present in 16.7% of patients. The results of the study were compared with the Ashok Kumar *et al.*[18] which also showed that knee pain was the most common symptom at presentation.

Table 13: Surgical Protocol

Author and year of publisher	Graft used	Femoral Fixation	Tibial Fixation	Duration of follow up
Hill [17] *et al.* (2005)	Quadruple Hamstring Graft	Titanium Screw	One group with Titanium screw and other with staple.	2 year
Ashok [18] *et al.* (2016)	BPTB graft / Four stranded Hamstring graft	Bioabsorbable Interference screw	Bioabsorbable Interference screw	6 month
Chidanand *et al.* [14] (2016)	Quadruple Semitendinosus graft	Endobutton	Suture disc	2 years
Shishir [20] M *et al.* (2016)	Quadruple Hamstring Graft	Endobutton	Bioabsorbable Interference screw	2 years
Jagtap *et al.* [15] (2017)	Single Bundle Semitendinosus graft	Endobutton	Suture disc	1 year
Agni *et al.* [19] (2017)	Quadruple Hamstring Graft	Endobutton	Titanium Screw/ Bioabsorbable Interference screw	1.5 year
Present study	Single Bundle Quadruple Hamstring graft	Endobutton	Bioabsorbable Interference screw and suture disc	6 months

Table 14: Post-operative anterior drawer test finding

Grade	Shishir [20] M *et al.* (2016), Percentage of patients	Present study
0	73.33	87.5
1	23.33	8.33
2	3.33	4.1
3	0	0

In our study 87.5% of the patients turned anterior drawer test negative when examined post operatively at 6 months

Table 15: Post-operative Lachman test finding

Grade	Shishir [20] M *et al.* (2016), Percentage of patients	(Present study), Percentage of patients
0	70	66.6
1	28.3	29.2
2	1.6	4.2
3	0	0

In our study 66.6% of the patients turned Lachman test negative when examined post operatively at 6 months

Table 16: Post-operative Pivot shift test finding

Grade	Shishir [20] M *et al.* (2016), Percentage of patients	(Present study), Percentage of patients
0	75	79.16
1	23.3	20.83
2	1.6	0
3	0	0

In our study 79.16% of the patients turned Pivot test negative when examined post operatively at 6 months.
We have used the Lysholm score and IKDC score for subjective evaluation of all our patients at each follow up. Follow up was done at 2 weeks, 8 weeks, 12 weeks,24 weeks

Lysholm score
The average Lysholm score at the end of our study and at last follow-up was 91.25 which was comparable with the above studies. There was clinically significant improvement in Lysholm Score 77.60 to 91.25. The measured Lysholm Score in Ashok[18] *et al.* study preoperative was 56.44 and

postoperative was 88.1 at the end of 6 months. In a study by Shishir M [20] *et al.* average preoperative score was 64.45 and post-operative at the end 6 months was 83.00 as shown in Table 17.

Table 17: Lysholm score

Study	Average Lysholm Score pre- operative	Average Lysholm Score post-operative
Shishir M [20] *et al*.	64.45	83.00 (6 months)
Ashok Kumar [18] *et al*. (2016)	56.44	88.1(6 months)
Present study	77.6	91.25 (6 months)

In our study, 83.3% had excellent functional outcome while 16.7% patients had good outcome. In the study by Hill *et al.*, 85.7% had excellent functional outcome while 14.3% patients had good outcome.

In a study by Chidanand [14] *et al*. 70% of patients had excellent outcome, 23.3% had good outcome and 6.6% had fair outcome at the end of the study. In a study by Jagtap [15] *et al*. 70% of the patients had excellent outcome, 20% had good outcome and 10% had fair outcome. In a study by Hill [17] *et al*. 61.9% had excellent outcome and 38.1% had good outcome.

Whereas in a study by Radhakrishnan *et al*. [22] where hybrid method of fixation was used excellent outcome was seen in 100% of the patients as shown in Table 18.

Table 18: Lysholm Score Results

Result	Excellent	Good	Fair	Poor
Hill [17] *et al*. (2005)	85.7%	14.3%	0	0
Chidanand [14] *et al*. (2015)	70%	23.3%	6.6%	0
Jagtap [15] *et al*. (2017)	70%	20%	10%	0
Radhakrishnan [22] *et al*. (2018)	100%	0	0	0
Present study	83.3%	16.7%	0	0

IKDC score comparison

In our study the mean pre-operative IKDC score was 55.60 whereas the post-operative score after 24 weeks was 86.13. There was significant improvement in post-operative IKDC score when compared with preoperative score. Our IKDC score was comparable with other studies [18, 21] as shown in Table 19.

Table 19: IKDC score comparison

Study	Pre-operative IKDC Score	Post-operative IKDC Score
Ashok Kumar [18] *et al*. (2016)	54.94	85.5
Prasad Aparajit [21] *et al*. (2016)	50.5	86.03
Present study	55.60	86.13

The advantages of bioabsorbable interference screw is there is no need to remove bioabsorbable screws as they would have been degraded and replaced with bone allowing revision surgery if required to be performed similar to primary procedure. These screws also avoid impairment of imaging [19]. Another advantage is decreased likelihood of graft laceration [21].

The main disadvantage of bioabsorbable screw is breakage of the screw while inserting and concerns over biocompatibility [24].

Tibial-sided hybrid fixation results in stronger, stiffer fixation immediately after ACL reconstruction. Hybrid fixation also seems to significantly reduce anterior laxity at midterm follow-up, without sacrificing range of motion[9].

Fixation strength in tibial tunnel is less than that in femoral tunnel, and it may not be enough to bear stress regarding that normal daily load in the intact ACL is approximately 450N[27]. Magen *et al.* reported that the failure load of interference screw, which was 350N, was not enough in tibia.

In our study, no major intraoperative complications like screw breakage, graft injury and aseptic effusion[19] were seen. In our study one patient had mild pain over the suture disc site due to irritation by ethibond and metal and no other complication such as superficial and deep infection noticed.

Conclusion

- In young active adults, anatomic single bundle reconstruction with quadrupled hamstring graft gives good functional results.
- Endobutton on the femoral side and Bioabsorbable interference screw and suture disc on the tibial end is a good mechanical and strong suspensory type of fixation device for ACL reconstruction.
- This technique offers an excellent knee function, knee stability and restoration of preoperative functional status with minimal complication. The patients undergoing hybrid method of fixation return to preinjury level of activity early.

We concluded from the study that anatomic single bundle reconstruction with quadrupled hamstring graft using suspensory femoral and hybrid tibial fixation gives good functional results. The patients undergoing hybrid method of fixation return to preinjury level of activity early.

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