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Functional evaluation of anterior cruciate ligament reconstruction with anatomical single bundle technique using quadrupled hamstring tendon

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Abstract

Objective: Anterior cruciate ligament injury is one of the commonest ligament injuries of knee joint. Arthroscopic acl reconstruction is indicated if patient presents with knee instability and wants to get back to active life style. Incidence of meniscal and chondral injuries is high in chronic acl injured knees .There is still debate on ideal acl reconstruction graft choice, graft fixation methods and tunnel making techniques . So we conducted an observational study on functional evaluation of arthroscopic acl reconstruction using single bundle of quadrupled hamstring graft fixed with endobutton at femoral side and with interference screw at the tibial side using transportal technique. **Materials and methods:** Arthroscopic acl reconstructed adult patients less than 60 years were included in the study . Those acl injuries in children and older patients with osteoarthritic changes and associated bony injury patients were excluded from the study. **Results:** There were 40 cases in the study with age ranging from 20 to 47 years with mean age of 31 years. Sports was the most common mode of injury. Isolated acl injury was found in 62.5 percent of cases and combined meniscus injury along with acl injury was found in 37.5 percent of cases in the study. Partial meniscectomy was done in 90 percent of cases while meniscus repair was done in 10 percent of cases. The time period from injury to surgery varies from one week to one year with mean time of 3 months. Patients were followed up for a minimum period of one year and evaluated with Lysholm score. The maximum score achieved was 95 and minimum score was 71. There is statistical significance between pre and postoperative lysholm scores and between associated knee injuries and lysholm score. All patients were able to return to their previous job at four months. **Conclusion:** Arthroscopic Acl

reconstruction with quadrupled hamstring graft fixed at anatomical site with endobutton at femoral side and with interference screw at tibial side leads to reproducible good functional results with minimum morbidity and helps patients get back to their previous job.

Keywords: Arthroscopic acl reconstruction; hamstring tendon; endobutton

1 Introduction

The Anterior cruciate ligament (ACL) is one of the commonest ligament injuries of knee joint accounting for 200,000 tears in a year¹. Incidence of ACL injury is increasing from 33 cases in 1994 to 50 cases in 2014 for 1,00,000 people^e. Those affected are mainly young patients involved in sports activity and road traffic accidents. This often leads to anterior knee instability and restriction of an active lifestyle and sports activity. ACL deficient knee is found to have an increased rate of secondary meniscus injury and chondral degeneration⁽¹⁻⁵⁾. There is a ten fold increase in the incidence of knee osteoarthritis after ACL tear as a natural course⁽⁶⁾. More than fifty percent of patients with an ACL injury will develop symptomatic osteoarthritis in the following ten to twenty years⁽⁷⁾. ACL reconstruction surgery is considered nowadays as gold standard surgery to provide knee stability and improve knee function. It helps to reduce progression of osteoarthritis but will not restore all knee functions as compared to uninjured knee as there are a lot of factors that play a complex role in the development of osteoarthritic changes like male gender, high BMI, time from injury to ACL reconstruction, presence of cartilage degeneration at the time of surgery and reconstruction technique.

Present-day surgical reconstruction techniques still provide a significant percentage of reconstruction failures, even if there is a considerable improvement in the results. Several technical aspects need further analysis to achieve the best results, such as graft choice for ACL reconstruction and transtibial or transportal method of femoral tunnel creation and whether to use single or double-

bundle ACL reconstructions and method of fixation of grafts.

Several published studies show controversies regarding the functional results and stability of different ACL reconstruction methods. The present paper tries to present an observational study of arthroscopic ACL reconstruction done using quadrupled hamstring graft in single-bundle anatomical reconstruction method and making a femoral tunnel independently using the transportal technique to evaluate the knee functional outcome.

2 Materials and methods

We evaluated 40 cases of arthroscopic ACL reconstruction operated at our institute, in Kanchipuram district Tamilnadu India from august 2017 to march 2019. Patients aged less than 60 years with complete ACL tear with or without meniscus injury are included in the study. Those patients of ACL injury with age > 60 years, multi ligamentous knee injury, open knee injury, knee deformity cases were excluded from the study.

Surgical technique

Pt is operated under spinal anesthesia. Diagnostic arthroscopy of knee joint is done under tourniquet control using standard anteromedial and anterolateral knee portals. Semitendinosus tendon is harvested by a separate anteromedial incision over proximal tibia and prepared it into a four stranded single bundle graft. Meniscus tear if present is managed according to the pathology- partial meniscectomy is done in old and complex meniscus tear while meniscus repair is done in young patients with recent peripheral tears of size larger than 1cm . Femoral tunnel is made just

posterior to lateral intercondylar ridge of lateral femoral condyle through transportal technique using accessory medial portal made just distal and medial to anteromedial portal. Tibial tunnel is made at the centre of tibial acl remnants in line with posterior border of anterior horn of lateral meniscus using acl jig with 60 degree angle. The graft is passed into tibial and femoral tunnels and fixed with endobutton at femoral tunnel and interference screw at the tibial tunnel.

3 Results

There were 40 cases in the study with age ranging from 20 to 47 years with a mean age of 31 years. There were 34 male cases and 6 female cases. The right knee was involved in 58 percent (23 cases) and the left knee was involved in 42 percent of cases (17 cases). The various modes of injury are illustrated in table 1. Isolated ACL injury was found in 62.5 percent of cases and combined meniscus injury along with ACL injury was found in 37.5 percent of cases in the study, details of which are provided in table 2. Partial meniscectomy was done in 90 percent of cases as the tear was old, complex and in the avascular zone and meniscus repair was done in 10 percent of cases. The period from injury to surgery varies from one week to one year with a mean time of 3 months.

Complications :

There were two cases of superficial wound infection at graft harvested site which settled with antibiotic therapy. one case had an intraoperative complication of the endo button that got engaged on fascia lata instead of fixing on the lateral cortex of femoral condyle which was noticed postoperatively for which endo button removal and interference screw fixation at the femoral side was done.

Statistical analysis:

Statistical Analysis was performed using SPSS 21.0 Version and Epi-Info 7.0. and student t-test and chi-square test were used to assess significant association and statistical significance was considered when the p-value was < 0.05.

Forty arthroscopic ACL reconstructed patients were followed up for a minimum period of one year and a maximum period of 1.5 years. All patients are evaluated with Lysholm and Gillquist scoring at the end of 12 months. The score evaluates patients' response to joint pain, swelling, limp, locking, support for walking, instability, squatting, stair climbing. The maximum score achieved was 95 and the minimum score was 71. The lysholm knee score is graded into four categories according to the score as shown in the table 2.

There is statistical significant improvement in postoperative functional lysholm score compared to preoperative scores as depicted in table 3. The postoperative lysholm score of the study participants ranged from excellent in 53 percent of cases to fair in 15 percent of cases as depicted in table 4. Associated meniscal injury patients scored low grade significantly as compared to isolated acl injury patients as shown in table 5. There is statistical significant association between sex and

mode of injury as sports and road traffic accident injuries are rare in female patients as shown in table 6.

The salient features of the study results are

- A greater number of our patients were seen in the younger age group of 20-40 years.
- Male preponderance was noticed in our study
- The right side was more affected when compared with the left side.
- Sports was the most common cause accounting for ACL injury.
- Medial meniscus injury was involved more than the lateral meniscus.
- Most of the patients returned to their pre-functional level at 4 months.

4 Discussion

Non-operative treatment of ACL injury has been associated with poor functional outcomes^(1-3,8) especially in young active patients who want to return to an active lifestyle and return to sports. ACL deficient knee is found to have an increased rate of secondary meniscus injury and chondral degeneration⁽¹⁻⁵⁾. One study⁽⁹⁾ which favored conservative treatment for ACL injury has reported an increased incidence of secondary meniscus tear and ACL surgery following instability complaints. Hence ACL reconstruction surgery is advocated for young active patients with an ACL injury.

The arthroscopic procedure has the advantage of reduced morbidity, reduced incidence of patellofemoral adhesions, decreased knee pain following reconstruction. Arthroscopy also has a technical advantage of better visualization of intraarticular structures and helps in accurate placement of tunnels and superior meniscus repair techniques. Cyril b Frank⁽¹⁰⁾ reported that arthroscopic reconstruction has a better functional outcome in the short term but the outcomes are not significantly different in the long term. But Hamid Barzegar⁽¹¹⁾ reported arthroscopic reconstruction is superior to a mini arthrotomy procedure in the time taken to return to pre-injury working level.

In our study, sports injury predominated as the cause of injury accounting for 45 % as compared to many international studies.

D W Lewis⁽¹²⁾ reported 58% of meniscal injury associated with an ACL tear at presentation. The medial meniscus was involved more than the lateral meniscus in his study and he also proposed meniscal repair or resection did not alter the outcome and chondral lesions are a better predictor of functional outcome. In our study, 40% of patients had a meniscal injury at presentation and medial meniscus injury predominated lateral meniscus injury like other studies. None of our patients had significant chondral damage at the time of surgery.

The fixation of the graft has been proved to be the site of failure rather than the graft itself irrespective of the type of graft especially in the early rehabilitation phase when the graft integration has not taken place and the fixation is of little significance after 8 to 12 weeks when graft has integrated with the bone as proposed by Dawn T Gulick⁽¹³⁾.

Various graft fixation devices have been developed in the recent past for soft tissue graft fixation which resulted in the increased reliability of soft tissue grafts and its use. Steiner et al⁽¹⁴⁾ proposed strong fixation as the key to success in soft tissue grafts. Petterikousa⁽¹⁵⁾ based on his biomechanical study comparing various fixation devices published that the Bone mulch screw is superior to any other device in providing stiffer fixation of soft tissue grafts and endo button second only to bone mulch screw. Multiple biomechanical studies^(16–21) support femoral cross pins as a superior fixation device for ACL, but there is a paucity of clinical data on long term follow up and various complications have been reported like pin migration and breakage, tunnel widening and joint protrusion. Endobutton femoral fixation showed good results that were comparable to those of cross pins fixation in hamstring ACL reconstruction⁽²²⁾. Whereas Young Ho et al⁽²³⁾ showed that a hybrid fixation with an endo button and a bioscrew in the femoral tunnel provided adequate stability and stiffness than either alone. Brown et al⁽²⁴⁾ reported that the strongest femoral fixation method was the Doubled gracilis and semitendinosus graft (DGST) graft fixed with the EndoButton CL device (1,345 N) and that the stiffest fixation was achieved with the bone-patellar-tendon-bone graft (BPTB) graft fixed with an interference screw (299 N/mm). Furthermore, in their study, the stiffness of soft-tissue interference screw fixation was not significantly different from that of interference screw fixation of BPTB grafts (255 N/mm). We used the endo button as the femoral fixation device and interference screw as the tibial fixation device. Though there are concerns about the bungee effect of the graft while using the endo button causing movement of graft in the tunnel, tunnel widening and interference to graft incorporation, a recent study Buelow et al.⁽²⁵⁾ had reported tunnel widening also occurs with an interference screw. Tunnel widening is attributed to multiple factors rather than mechanical factors of the fixation device alone according to Ma et al and Wilson et al^(26,27). In our study, there were no pullout or graft fixation site failures and the endo button was able to withstand the post-operative rehabilitation.

Time of surgery

There is an increased incidence of about 20 to 30 percent^(28,29) of ACL injury patients going for secondary meniscus and chondral injuries and loss of muscle strength due to inactivity when ACL surgery is delayed for one year.

Arthrofibrosis which means joint stiffness results from early ACL reconstruction surgery operated within 3 weeks after injury^(30,31). Hence the ideal time for surgical treatment

is 3 to 6 weeks after the ACL injury. All the cases in our study were operated after 3 weeks postinjury and no arthrofibrosis were found in our study. But we operated 70 % cases after 6 weeks and had 30 % meniscus injury which may be due to initial injury or post ACL injury sequelae as the patient presented to us late and immediate post-injury MRI was not available.

Type of graft

The patellar tendon and hamstring tendon grafts are mostly used nowadays for ACL reconstruction surgery. Each type of graft has its advantages and disadvantages but meta-analysis studies show both grafts work very well concerning functional outcomes.

Biomechanical data⁽³²⁾ shows that patella tendon graft had a maximum load of 2730 – 2900N and stiffness of 57mpa which is 170% stronger and 150% stiffer than native ACL. A single strand of hamstring tendon graft (semitendinosus and gracilis) had 1220 N & 840 N load and 89 mpa & 112 mpa corresponding to 70% and 49 % of native ACL for load property and 234% and 295 % of native ACL for stiffness. The use of quadrupled hamstring tendon strands resulted in doubling the load and stiffness property than that of native ACL and it is a safe option.

A meta-analysis⁽³³⁾ 50 showed a 1.9 % graft failure for patellar tendon and 4.9% graft failure for hamstring tendon. But other studies showed no significant difference in the retear rate between these two grafts^(34,35).

Another meta-analysis⁽³³⁾ showed KT 1000 arthrometer side to side difference < 3 mm was less with patellar tendon graft than with hamstring tendon graft(73.8% versus 79% respectively). One more meta-analysis showed patellar tendon graft restored knee stability better with less risk of pivot shift test.

But on the downside, Patellar tendon graft is also associated with anterior knee pain and kneeling pain as donor site morbidity as shown in a meta-analysis of 12 studies including 850 patients⁽³⁶⁾. This is a consistent finding repeated in many other studies.

Hamstring graft has lower donor site morbidity though it is technically demanding for harvesting with small skin scar. Most reports suggest regeneration of hamstring graft within two years whereas patellar tendon graft regeneration may take a prolonged time^(37–40). Tunnel widening was more with the hamstring tendon graft than with the patellar tendon graft. (20% versus 10% respectively). Though tunnel widening was reported in many random controlled studies^(8,41,42) significant knee laxity was found in one study 47 %⁽⁴³⁾. Filling the tunnel with autologous bone was found to reduce femoral tunnel widening. An animal study⁽⁴⁴⁾ highlighted that graft remodeling and hypertrophy led to femoral tunnel widening.

All our cases are treated with autograft using quadrupled hamstring tendon as a single bundle and found no knee instability greater than grade 1 by Lachman and Drawer tests and

no knee instability as reported by patients in Lysholm score. There is 10 % of cases of tibial tunnel widening were noted in our study too.

Allograft has no donor site morbidity, shorter surgical time and less incidence of graft length and diameter issues which are all advantages but it has a high graft failure rate of about 4 times than autograft as shown in a study⁽⁴⁵⁾. It is found that graft irradiation and chemical processing are critical factors for the high failure rate⁽⁴⁶⁾. Allograft has also a high infection rate and high tear rate as per studies^(47,48) and also unavailable in many cities in India.

An ideal position for the femoral tunnel is given much importance recently.

Ideal stands for

I - isometry, D - direct, E - eccentric, A - anatomical, L - low tension

ACL fibers vary in length and tension in knee flexion and extension movements. It is found that anteromedial bundles are more isometric with the least change in length than the posterolateral bundle and is considered the center of rotation of ACL⁽⁴⁹⁾. This isometric anterolateral bundle is located eccentrically at the most anterior and superior aspect of the native femoral ACL footprint⁽⁵⁰⁻⁵²⁾. The femoral attachment of ACL is found to have strong direct fibers anteriorly attaching to the lateral condylar ridge and weak indirect fibers attaching it posteriorly⁽⁵³⁾. Hence direct anterior fibers are replicated in surgery. Proper positioning of the ACL graft is very much critical in ensuring graft longevity as it avoids graft impingement with intercondylar roof in knee extension and with PCL in knee flexion. Hence anatomical native ACL footprint attachments are imitated in recent surgeries. To avoid high loading of graft in knee movements, too posterior and too low position of femoral tunnel is avoided instead keeping it anteriorly juxtapositional to the lateral condylar ridge is favored⁽⁵⁴⁾.

Anatomical femoral footprint location at the junction of the lateral intercondylar ridge and bicondylar ridge was used in our study by using an accessory medial portal.

In two meta-analysis reports, Xu et al⁽⁵⁵⁾ and Li et al⁽⁵⁶⁾ compared single and double-bundle ACL reconstruction and found, increased rotational stability, IKDC and KT arthrometer scores with double-bundle technique but regarding functional recovery related to Lysholm and Tegner activity score, there is no significant difference in results.

All our cases are operated with anatomical single bundle quadrupled hamstring tendon grafts and patients reported no subjective knee instability in their daily activities and the Lysholm score is comparable to other studies using the single-bundle technique.

The limitations in our study are short term one year study and objective arthrometer stability testing could not be done and most of our patients are recreational sportspersons.

5 Conclusion

Arthroscopic ACL reconstruction with single bundle quadrupled hamstring graft fixed at the anatomical site with an endo button at the femoral side and with interference screw at the tibial side leads to reproducible excellent functional results with minimum morbidity and helps patients get back to their previous job.

Conflict of interest:

The authors declare that there fund has not been received from any source for preparing and publishing the manuscript and there is no conflict of interest.

Table 1. Various mode of injury of acl patients

Mode of injury	Patients	Percentage
Sports	18	45.0
Fall	10	25.0
Road traffic accident	12	30.0
TOTAL	40	100.0

Table 2. The Lysholm knee score is graded as

Lysholm score grading	Points
Excellent	91 -100
Good	85 - 90
Fair	65 - 84
Poor	< 65

Table 3. Comparison between Pre and post-operative Lysholm score

Paired Samples Statistics						
		Mean	N	SD	Student t Test	P Value
Pair 1	Pre Operative	51.88	40	7.086	21.799	0.001 ***
	Post Operative	90.08	40	6.840		

***There is Highly Statistical Significance Difference between Pre and Post Operative score at 95% (P < 0.05).

Table 4. Postoperative Lysholm knee score grading of the study

Results	Patients	Percentage
Excellent	21	52.5
Good	13	32.5
Fair	6	15.0
TOTAL	40	100.0

Table 5. Association between associated meniscal injury and post-operative Lysholm score results.

			Results				Chi Square Test	P Value
			Excellent	Good	Fair	Total		
Associated Injury	Medial Tear	Meniscus	4(19.0)	2(15.4)	2(33.3)	8(20.0)	21.046 df	0.002**
	Lateral Tear	Meniscus	2(9.5)	2(15.4)	0(0.0)	4(10.0)		
	Both		0(0.0)	0(0.0)	3(50.0)	3(7.5)		
	Nil		15(71.4)	9(69.2)	1(16.7)	25(62.5)		
	Total		21(100)	13(100)	6(100)	40(100)		

** - There is a Statistical Significance Association between Associated Injury and Results at 95% (P < 0.05)

Table 6. Association between gender and mode of injury

		MODE OF INJURY				Chi Square Test	P Value
		Sports	Fall	RTA	Total		
Sex	Male	17(94.4)	5(90.0)	12(100)	34(85.0)	12.982df	0.002**
	Female	1(5.6)	5(50.0)	0(0.0)	6(15.0)		
	Total	18(100)	10(100)	12(100)	40(100)		

** - There is a Statistical Significance Association between Sex and Mode of Injury at 95% (P < 0.05).

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