



Assessment of Functional Outcome of Arthroscopic Assisted Anterior Cruciate Ligament Reconstruction Using Quadrupled Hamstring Tendon Graft

Dr Lionel John J¹, Dr Suriya kulothungan K^{2*}, Dr Karthik M³

1. Department of Orthopaedics, professor, unit chief, Sree Balaji Medical College and Hospital, Chrompet, Chennai, India
2. *Department of Orthopaedics, Final year resident, Sree Balaji Medical College and Hospital, Chrompet, Chennai, India
3. Department of Orthopaedics, Assistant professor, Sree Balaji Medical College and Hospital, Chrompet, Chennai, India

*denotes corresponding author

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KEYWORDS

anterior cruciate ligament, semitendinosus, gracilis, quadrupled hamstring graft, IKDC score.

ABSTRACT:

Introduction: ACL injuries are a prevalent concern in orthopaedic practice, particularly among athletes and individuals involved in physically intensive activities. The ACL is essential for maintaining knee stability, and its injury can result in considerable functional loss. Arthroscopic ACL reconstruction using a quadrupled hamstring tendon graft has gained attention due to its efficacy in restoring knee function with minimal complications at the donor site. This study is aimed to evaluate functional outcomes of ACL restoration utilizing this grafting approach.

Methods: This prospective study was conducted at Sree Balaji Medical College and Hospital between June 2022 and June 2024, involving 30 patients with ACL injuries who underwent arthroscopic ACL reconstruction using a quadrupled hamstring tendon graft. Participants evaluated preoperatively & postoperatively at 1, 3, 6, 9 and 12 months. Functional outcomes were assessed using International Knee Documentation Committee (IKDC) score. Postoperative rehabilitation protocol involved progressive weight-bearing and physical therapy exercises to enhance knee strength and mobility.

Results: The study included 30 participants, with an average age of 34 years, the majority being male (76.67%). The leading cause of injury was road traffic accidents (46.67%), followed by slips and falls (30%). Postoperative results showed significant functional improvement, with the mean IKDC score increasing from 45 preoperatively to 92 postoperatively. 40% of patients achieved excellent outcomes, and 50% had good outcomes.

Conclusion: Arthroscopic ACL reconstruction using a quadrupled hamstring tendon graft yields excellent functional outcomes, particularly in young and active individuals. This technique provides robust knee stability, minimal donor site complications, and a high rate of restoring pre-injury function. Further long-term studies are recommended to evaluate durability of these positive outcomes.

I. INTRODUCTION:

The knee functions as a hinge-like synovial joint, primarily facilitating flexion and extension movements. A key ligament responsible for knee stability, the anterior cruciate ligament (ACL), plays vital role in maintaining

both dynamic and static stability, as well as coordinating knee movements. Its primary function is to prevent forward translation of tibia relative to femur. Therefore, ACL is essential for normal knee function, and its injury



can result in functional deficits and potentially accelerate joint degeneration[1].

This joint part bears most of the body's weight. Hence, this knee joint is susceptible to both acute injuries and the development of osteoarthritis. The ACL is an essential ligament that ensures proper movement in the knee joint. Therefore, knee instability due to ACL injuries is more common than those resulting from injuries to other knee ligaments[2]. Most of the injuries are due to noncontact tears or ruptures. The most common mechanism of an ACL injury occurs through excessive bending or twisting at the knee, but there are several causes of an ACL tear. ACL tears are most common in people over forty due to wear and tear, but they also occur in older adults by slipping or falling. ACL tears tend to occur when the leg is stationary on the ground, and the knee absorbs a blow from the front. The injuries are often associated with a hard or awkward landing and with twisting or turning of the knee upon hitting the ground, especially in a valgus position[3].

The ACL injury causes disruption to movement patterns of the knee, causing the joint to become unstable and susceptible to cartilage damage and meniscus injuries.. The most common autografts utilized for primary ACL restoration are bone-patellar tendon bone and hamstring tendon. Although several clinical studies have been done on ACL reconstruction, a clear choice for the best graft in repair of ACL injuries still continues to be controversial.[4,5]

II. METHODOLOGY AND MATERIALS:

This was a prospective study on patients with torn Anterior Cruciate Ligament (ACL) treated with arthroscopic assisted ACL restoration at our hospital, Sree Balaji Medical College and Hospital(SBMCH)

between June 2022 to June 2024 and ascertained the inclusion criteria. The study spanned 12 to 18 months and included 30 cases. The patients were evaluated preoperatively and postoperatively at 1, 3, 6, 9, 12 months using IKDC score.

A. INCLUSION CRITERIA:

- Patients diagnosed with isolated ACL injuries.
- Primary ACL surgery
- between 20 and 60 years of age
- Sex: Male and Female

B. EXCLUSION CRITERIA:

- Patients with pacemaker, ferromagnetic implants, aneurysm clips
- Knee joint tumours
- Active systemic / local infections
- Diagnosed inflammatory pathology of the knee.

On admission to SBMCH, the patient's appropriate history and clinical examination were taken. Clinical examinations include special tests like the Anterior drawer & Lachman test for ACL, posterior drawer test for PCL, McMurray's test for meniscus, varus & valgus stress test for collaterals. All relevant radiological assessments to confirm the diagnosis were done, including preoperative knee X-rays in anteroposterior and lateral projections and an MRI scan. All patients were preoperatively assessed with IKDC score and Lysholm score. Follow-up observations done at 3, 6 months, and 1 year follow-up periods. IKDC and Lysholm scores were used to evaluate the postoperative functional outcome.





C. IMAGING:

In all of our cases we took x-ray knee- Anteroposterior view and lateral view as initial radiological investigation.

Followed by an MRI(Magnetic Resonance Imaging) of the knee. All cases are postoperatively followed by x-ray knee lateral & AP view to verify endobutton and screw position.



Fig 1: preoperative mri

D. SAMPLE SIZE CALCULATION

A maximum permissible convenience sample within a stipulated time frame was included in the study.

E. SURGICAL PROCEDURE:

Procedures were carried out by a skilled surgeon using 4 mm, 30° arthroscope. The ipsilateral semitendinosus tendon, as well as the gracilis tendon if semitendinosus length was less than 260 mm, harvested following diagnostic arthroscopy. Both tendon ends were secured by a Krackow-type whipstitch, then tendon was overlapped to form four strands. Femoral tunnel was created by an anteromedial portal(independent). A beath pin was inserted through femoral aimer at 2 o'clock position on left side and 10 o'clock position on right side in order to target the midpoint between posterolateral (PL) & anteromedial(AM) bundle insertion. The tunnel

was drilled over beath pin using 4.5-mm reamer, and the socket reamed according to the graft dimension. Tibial guide placed at 50 to 55 degrees and positioned posteriorly over stump footprint to prepare tibial tunnel. Guide pin was drilled through stump. Tibial tunnel was reamed to accommodate for graft diameter. Intra-articular edges of tunnels were smoothed by an automated shaver. A surgical marker outlined femoral end of graft as the site for flipping EndoButton. Ethibond sutures were passed through the EndoButton, and then gradually pulled out from lateral side of thigh with a camera demonstrating the graft. EndoButton was flipped over and secured to lateral femoral cortex. Fixation of tibia was achieved in 30 degrees of flexion by using a bioabsorbable screw 1 mm smaller than tunnel after cycling the knee for three minutes.



Fig 2: patient positioning



Fig 3: harvested graft

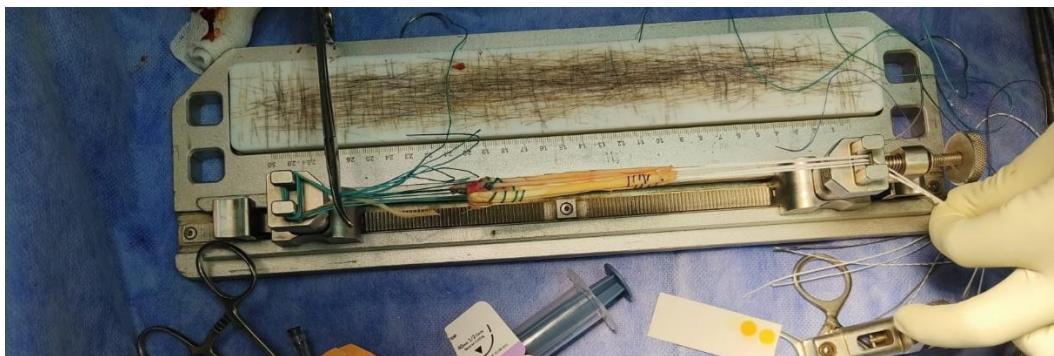


Fig 4: quadrupled hamstring tendon graft

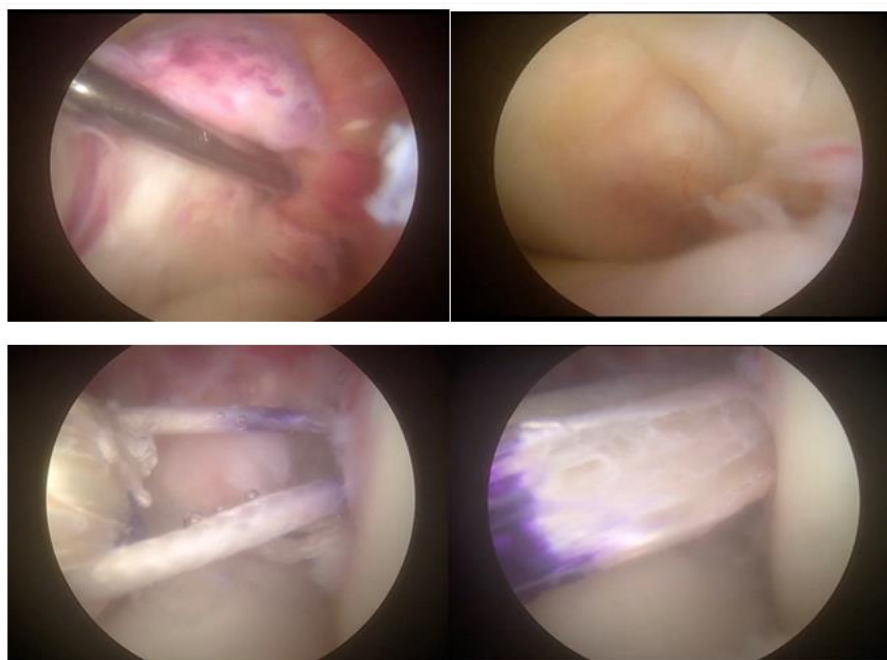


Fig 5: intraoperative arthroscopic images



F. POSTOPERATIVE PERIOD:

Postoperative X-rays were made to ensure that the implant and the tunnel were properly placed. Knee range of motion braces were prescribed for all patients.

Generally, full knee extension and a ROM of 90° of knee flexion by the end of the first two weeks was recommended. In addition, the performance of effective quadriceps contractions was encouraged, as well as straight leg raises in all directions and standing hamstring curls. Partial weight-bearing on the affected limb with crutches while wearing a long knee brace was also recommended.

Between 2 and 4 weeks, straight leg raises (SLR) with weights and standing hamstring curls with weights was recommended. Knee extensions were done with the help of manual resistance from the therapist, and ROM progressed to up to 120° at the end of 4 weeks. Patient was encouraged full weight-bearing and was discharged with crutches, which were discontinued if no limp was present.

From 4 to 6 weeks progress closed chain exercises and progress to full ROM by 6 weeks. Begin isokinetic hamstring progression and quadriceps work 90 to 40° isokinetics and stairmaster.

Between 8 and 10 weeks, the aforementioned exercises were progressed. Patients were introduced to lunges and

participated in isokinetic quadriceps strengthening at different speeds.

From 12 to 16 weeks, complete range isokinetic exercises were introduced. Isokinetic quadriceps strengthening was gradually advanced to achieve full extension by the end of 16 weeks.

Between 16 and 20 weeks, a plyometric program was started with the aid of equipment like shuttle, mini trampoline, and jump rope; however, these were based on the criteria that the quadriceps strength reached 65% with no joint swelling, full ROM, and a stable knee. In addition, a jogging program was started if the quadriceps strength was at least 65%.

Between 20 and 36 weeks, agility drills as well as sport-specific training were introduced into the treatment program. Agility testing was conducted at 36 weeks, at which time the patient may return to sport if the knee has more than 130° of motion; hamstring strength is >90%; and quadriceps strength is >85%.

Maintenance exercises should be performed two to three times per week.

At every follow-up appointment, the clinical assessment was performed using IKDC score, Lachman test, anterior drawer test, and compared against the preoperative scores obtained.[6]



Fig 5: post-operative xray



III. POSTOPERATIVE FOLLOW-UP AT 1 YEAR:



Fig 6: knee flexion in supine



Fig 7: knee extension with hip flexion in supine



Fig 8: Squatting



Fig 9: Sitting crossed leg

IV. RESULTS:

30 patients who had ACL reconstruction in the study period were analyzed in the study. Demographic data are enumerated in Table 1.



Demographic parameters		Results
Age(in years)	Mean+-standard deviation	34
	Range	23-52
Gender	Males	23(76.67%)
	Females	7(23.33%)
Side involvement	Right	17(56.67%)
	Left	13(43.33%)
Mode of injury	Road traffic accident	14(46.67%)
	Slip and fall	9(30.00%)
	Sports(kabaddi)	3(10.00%)
	Sports(football)	2(6.67%)
Associated tear	Isolated ACL injury	30(100%)
	Medial meniscus	-
	Lateral meniscus	-
	Both meniscus	-
Injury Surgery interval	Mean(range)	5.7 months (0-24 months)
Graft harvested	Both gracilis and semitendinosus	30(100%)

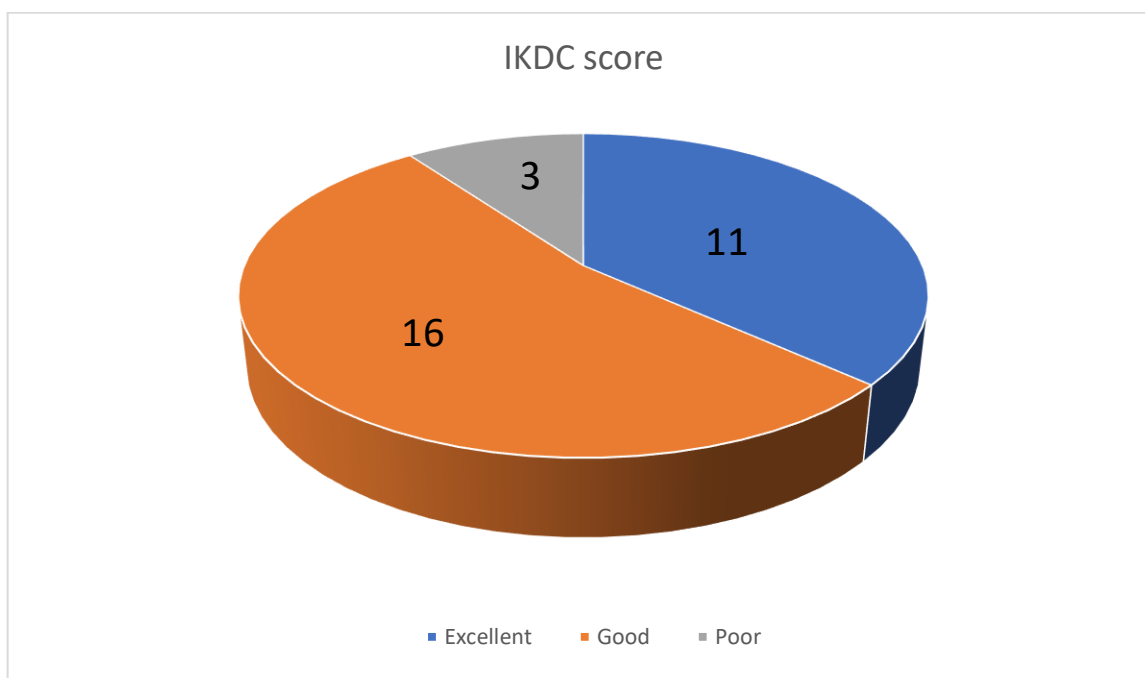
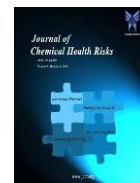
TABLE 1: DEMOGRAPHIC PARAMETERS OF THE PATIENTS

The mean IKDC score significantly (p -value <0.0001) increased postoperatively, from 45 preoperatively to 53 (at 1 month), 70 (at 3months), 75 (at six months), 83 (at 9 months) and finally 92 (at 12 months). There were no intraoperative and postoperative complications in our study.

FOLLOW-UP PERIOD	MEAN IKDC SCORE	p-value
Preoperative period	45	0.06
1 month	53	0.03
3 months	70	0.04
6 months	75	0.09
9 months	83	0.06
12 months	92	0.009
		Overall p-value: 0.01

TABLE 2: MEAN IKDC SCORE WITH p-value

There is significant improvement among patient when followed from pre-operative to 12 months postoperative period with p -value 0.01. The postoperative comparison Mann whitney U test is used showing improvement postoperatively in above table.



V. DISCUSSION:

Arthroscopic quadrupled graft fixation in ACL injuries has proven to increase the tensile strength of the graft, as well as it increased the stability of the knee joint. Thereby providing a stable & early recovery to activities and for other sporting activities. Thus far, multiple techniques have been described involving the use of quadruple-bundle hamstring graft in ACL restoration. Using either GC or ST, or both gracilis (GC) & semitendinosus (ST) tendons can also be used. In routine quadruple-bundle technique, a tendon length of 27 cm is required to achieve appropriate graft length. When one tendon is not big enough to form an adequate graft, the surgeon can harvest the second tendon and combine and create an adequate or bigger graft[7]. Lower body weight and smaller heights were significantly related to smaller diameters of the gracilis (GC) graft. Smaller diameters of the semitendinosus (ST) graft were significantly associated with female gender and lower weight[8]. This quadrupled hamstring tendon graft has some advantages, of which the foremost is the increased possibility of achieving adequate size of the graft in smaller diameter tendons, thereby minimizing the necessity for allograft augmentation or substitution and obviating additional surgical approach[9]. The reconstruction can be performed using the semitendinosus and gracilis tendons as four-strand hamstring autograft or just by using the

semitendinosus. It has been known that the average diameter of the native ACL is about 11 millimeters in diameter and about 32 millimeters long. For prevention of surgical revisions, the graft should be of at least 8 millimeters thickness and of length about 28 millimeters[10]. However, with conventional methods, most patients' natural tendons are too small for this thickness. There are very few choices in the treatment of a hamstring graft that is too small. A smaller graft may be used, but this obviously increases the risk of rupture. Another alternative has been to augment the autograft with allograft.

Our study highlights the preparation of the graft by combining both the ST & GC tendons, forming quadruple tendon structure, thus significantly increasing the graft diameter without need for allograft use. In this study, ACL tears were treated by anatomical single-bundle ACL reconstruction using quadrupled hamstring (semitendinosus & gracilis) tendon graft. Independent transportal technique was applied for the femoral tunnel creation. The quadrupled hamstring tendon autograft (HTG) is fixed at the femoral site with an endoButton and tibial site with a bioabsorbable screw. Young Ho[11] stated hybrid technique of using a combination of endo-button and bio screw in femoral tunnel is ideal in terms of stiffness and stability. According to Weiler,



bioabsorbable round contoured screws are better than the titanium interference screws.

The patient group consists of mostly males at 76.67% while females form 23.33%. The leading causes of injuries were road traffic accidents and slips or falls at 46.67% and 30% respectively. This is consistent with prior studies where it indicates that, in developing countries, non-sports-related injuries are more frequent than in the Western regions where athletic injuries are more prevalent. Kabbadi formed 10% of sports-related injuries, followed by football at 6.67%. The age distribution was relatively balanced in the 21-40 year range, suggesting that ACL injuries are common among young to middle-aged adults for most activities. Surgery occurred within 4 to 6 months post-injury in 53.3% (n=16) of cases. Right knee was involved in 17 patients (56.7%), & the left knee in 13 (43.3%). In addition, 14 patients (46.7%) had associated meniscal tears, of whom most were with the medial meniscus. Importantly, no patients in this study showed extensive chondral damage.

The findings of this study were compared with those of Prasad[12] et al. and Aparajit[13] et al. 2016. Mean age of patients at time of surgery in this present series was 34 years, similar to that reported by Aparajit et al. but greater than the mean age reported by Prasad et al. Mean follow-up period in our study was 16 months, ranging from 12 to 22 months. In comparison, the average follow-up period reported by Prasad et al. is 6 months. A study done by Aparajit (2016) documented a mean duration of 17 months. In this study,

In our study, mean preoperative IKDC score was 45, whereas mean postoperative score showed marked improvement up to 92. Similar studies were conducted by Prasad et al[12]. who found mean preoperative IKDC score was 42.45, whereas Aparajit et al[13]. had a score of 50.5. Post-operative scores were 94.33 and 86.03 in these studies, respectively.

With 1 year of follow-up our case series does not show any major complications and graft failure or rupture.

VI. CONCLUSION:

In conclusion, the quadrupled hamstring tendon graft is a highly effective and reliable option for ACL reconstruction, offering benefits such as increased graft size, reduced reliance on allografts, and avoidance of

additional surgical approaches. These advantages, coupled with the excellent biomechanical properties of the graft, make it an ideal choice for patients **seeking** to regain knee stability and function while minimizing the risk of complications.

VII. FINANCIAL SUPPORT

There is no funding source for this study.

VIII. INFORMED CONSENT

Consent from all the patients have been obtained for publishing their details in this case series.

IX. CONFLICT OF INTEREST

No conflicting interest are acknowledge by the author.

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XI. AUTHORS'S CONTRIBUTION

Formal analysis, writing, data collection, supervision, methodology, and resources: Professor Dr. Lionel John J

Writing, Investigation, Resources, Analysis, Draft preparation, Review and Editing: Dr Suriya kulothungan K

Composing, Research, Materials, Evaluation, Data Gathering, Assessment, and Guidance: Dr. Karthik M

Each author has read the document and given their consent to submit it.

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