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Original Article

Functional outcome of Central Quadricep Tendon Autograft technique for anterior cruciate ligament reconstruction

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ABSTRACT

Background: Anterior cruciate ligament is most common ligament that gets injured in knee joint. Rupture of Anterior cruciate ligament leads to knee instability, recurrent giving-way episodes, and impaired functional performance which significantly affects the quality of life. When conservative management fails, anterior cruciate ligament reconstruction using central quadriceps tendon as primary graft has emerged as a reliable surgical technique to restore knee stability, function, and return to activity, owing to its favorable biomechanical strength and low donor-site morbidity.

Purpose: To evaluate functional outcomes of central quadricep tendon autograft technique for anterior cruciate ligament reconstruction

Method : A prospective study was conducted over a period of approximately 18 months. A total of 15 patients aged between 18 and 45 years with anterior cruciate ligament rupture, fulfilling the selection criteria, were included in the study. All patients were admitted to the Department of Orthopaedics at a tertiary health care hospital in Surat and underwent anterior cruciate ligament reconstruction using a central quadriceps tendon autograft technique.

Conclusion: The central quadriceps tendon autograft provides a thicker and stronger graft, improving graft strength and resistance to failure in ACL reconstruction. Smaller hamstring grafts, particularly those around 7 mm in diameter, have been associated with higher failure rates. This approach eliminates the need for additional graft harvesting or allografts while maintaining adequate graft strength.

Results : The study demonstrates that anterior cruciate ligament reconstruction using a central quadriceps tendon autograft provides significant functional improvement, high rates of return to sport, and a low incidence of graft-related complications at mid-term follow-up.

A statistically significant improvement in postoperative functional outcome scores ($p < 0.001$) indicates effective restoration of knee stability and function. The majority of patients were able to return to their pre-injury level of sporting activity without residual instability or giving-way symptoms, highlighting the reliability of the quadriceps tendon as a load-bearing graft in high-demand individuals such as athletes.

The low graft failure rate observed in this study is consistent with previously published literature, which reports comparable or lower failure rates for quadriceps tendon autografts when compared with hamstring tendon. The larger cross-sectional area and superior tensile strength of the quadriceps tendon may contribute to enhanced graft durability and resistance to elongation.

Donor-site morbidity was minimal, with fewer complaints of anterior knee pain or

kneeling discomfort compared to hamstring grafts. Preservation of hamstring integrity avoided postoperative hamstring weakness, which is commonly reported with hamstring autograft techniques. Although mild quadriceps weakness was noted in the early postoperative period, this improved with structured rehabilitation and did not adversely affect long-term functional outcomes.
The versatility of the central quadriceps tendon autograft, allowing both all–soft tissue and bone-plug configurations, provides surgeons with flexibility in fixation methods and graft sizing. This is particularly advantageous in athletic patients and revision cases where larger graft diameter is desirable.

Keywords*: ACL reconstruction, quadriceps tendon autograft, knee instability, graft choice, sports injury.*

INTRODUCTION

The anterior cruciate ligament is essential for knee stability, particularly during rotational and pivoting activities. Surgical reconstruction is indicated in young, active individuals with symptomatic instability. Graft selection remains a subject of debate. While hamstring and BPTB grafts are widely used, each has associated drawbacks such as hamstring weakness, anterior knee pain, and kneeling discomfort.

The quadriceps tendon autograft, first described in the 1970s, has re-emerged as a reliable alternative with evolving minimally invasive harvesting techniques and improved fixation methods.

Aim

To assess the clinical and functional outcomes, rate of return to sports, and graft-related complications following anterior cruciate ligament reconstruction using a central quadriceps tendon autograft.

Methods

Study design and setting, patients, preoperative assessment, surgical technique, postoperative rehabilitation, outcome measures, and statistical analysis are described.

Study Design

This was a prospective observational study done over a period of 18 months from January 2024 to July 2025 conducted in the Department of Orthopaedics at Tertiary Care Hospital, Surat.

Study Population

All the patients who had ACL tear and admitted in Department of Orthopaedics at Tertiary Care Hospital, Surat, Gujarat, during the mentioned study period and fulfilling the selection criteria mentioned below were recruited for the study.

Study Duration: 18 months

Inclusion criteria

- Confirmed ACL Tear
  - Patients with complete or partial anterior cruciate ligament rupture confirmed by MRI or arthroscopy.
- Age Range
  - Typically 18–45 years (skeletally mature adults).
  - Younger patients may be considered if growth plates are closed; older patients should have good functional demand.
- Functional Instability
  - Patients experiencing knee instability, giving way, or recurrent episodes during daily activities or sports.
- Activity Level
  - Moderate to high activity individuals, including athletes or physically active patients who require knee stability.
- Suitable Quadriceps Tendon
  - Adequate central quadriceps tendon thickness (usually ≥7 mm) confirmed by preoperative imaging or intraoperative assessment.
  - Intact extensor mechanism without prior quadriceps tendon injury.
- Primary or Revision ACL Reconstruction
  - Can be used for primary ACL reconstruction.
  - Suitable for revision cases where hamstring or patellar tendon grafts are unavailable or previously used.
- Patient Consent
  - Informed consent for autograft harvesting, including understanding potential donor site morbidity (e.g., anterior

knee pain, quadriceps weakness).

- Time from Injury
  - Typically chronic or acute ACL tear, provided there is no significant arthritis or multi-ligament instability that contraindicates isolated ACL reconstruction.
- General Health Criteria
  - No systemic conditions affecting healing (e.g., uncontrolled diabetes, immunodeficiency).
  - No active infection in the knee or systemic infection.

- Willingness for Postoperative Rehabilitation
  - Ability and commitment to follow standard ACL rehabilitation protocol for optimal outcome.

Exclusion criteria

- Skeletally Immature Patients

Open growth plates (physis) that could be damaged during graft harvesting or tunnel drilling.

- Previous Quadriceps Tendon Injury or Surgery

History of quadriceps tendon rupture, tear, or prior harvesting for surgery.
Scarring or tendon weakness that would compromise graft quality.

- Severe Osteoarthritis or Knee Degeneration

Advanced cartilage loss (Kellgren-Lawrence grade III–IV) or degenerative changes that impair functional outcome after ACL reconstruction.

- Multi-Ligament Knee Injuries

Concomitant PCL, MCL, LCL, or posterolateral corner injuries requiring complex reconstruction unless staged or part of combined reconstruction protocol.

- Chronic Infection or Active Inflammatory Joint Disease

Septic arthritis or chronic osteomyelitis.
Rheumatoid arthritis or other inflammatory arthropathies affecting tendon healing.

- Systemic Health Issues Affecting Healing

Uncontrolled diabetes mellitus, immunosuppression, or vascular insufficiency.
Coagulopathy or bleeding disorders that increase surgical risk.

- Inadequate Quadriceps Tendon Size

Tendon thickness <7 mm or insufficient length for graft preparation.
Poor tissue quality observed intraoperatively.

- Neuromuscular Disorders

Conditions affecting quadriceps function or knee stability (e.g., polio, stroke, neuropathies).

- Previous Knee Surgery Limiting Graft Harvest

Patellar fracture or previous ACL reconstruction that compromises extensor mechanism or quadriceps tendon.

- Non-Compliance or Inability to Participate in Rehabilitation

Patients unwilling or unable to follow postoperative physiotherapy protocol.
Lifestyle or occupational limitations preventing proper recovery.

- Pregnancy

Elective surgery is usually postponed due to anesthesia and postoperative rehabilitation considerations.

Scoring System

Knee Society Score (KSS): Combines a Knee Score (pain, ROM, stability, alignment) and a Function Score (walking, stairs) for total 100 points each, widely used for arthroplasty outcomes.

Knee Findings		
Pain	**50 (Maximum)**	
Walking (insert the value associated with the results of question 1)		
None	35	
Mild or occasional	30	
Moderate	15	
Severe	0	
Stairs (Result of question 2)		
None	15	
Mild or occasional	10	
Moderate	5	
Severe	0	
R.O.M.	**25 (Maximum)**	
(Results of question 9)		
50 = 1 point		
Stability	**25 (Maximum)**	
Medial/Lateral (Result of question 12)		
0-5 mm	15	
5-10 mm	10	
>10 mm	5	
Anterior/Post (Result of quesiton 13)		
0-5 mm	10	
5-10 mm	8	
>10 mm	5	
Deductions		
Extension lag (Result of question 10)		
None	0	
<4 degrees	-2	
5-10 degrees	-5	
>11 degrees	-10	
Flexion Contracture (Result of question 11)		
<5 degrees	0	
6-10	-3	
11-20 degrees	-5	
>20 degrees	-10	
Malalignment (Result of question 14)		
5-10 degrees	0	
(5° = -2 points)		
Pain at rest (Result of question 3)		
Mild	-5	
Moderate	-10	
Severe	-15	
Symptomatic plus objective -0		
(Now, simply total the scores of each of these quesitons to obtain the total Knee Score of the patient)		
Knee Score	100 (Maximum) =	
Function Findings		
Walking (Result of question 4)		
Unlimited	55	
10-20 blocks	50	
5-10 blocks	35	
1-5 blocks	25	
<1 block	15	
Cannot	0	
Stairs Up (Result of quesiton 5)		
Normal	15	
Hands balance	12	
Hands pull	5	
Cannot or bizarre		
Stairs Down (Result of quesiton 6)		
Normal	15	
Hands balance	12	
Hands hold	5	
Cannot or bizarre	0	
Chair (Result of question 7)		
Normal	15	
Hands balance	12	
Hands pull	5	
Cannot	0	
Functional Deductions (Result of question 8)		
Cane	-2	
Crutches	-10	
Walker	-10	
Functional Score	100 (Maximum) =	

Surgical technique

Anterior cruciate ligament reconstruction using a central quadriceps tendon autograft is a standardized arthroscopically assisted procedure that is frequently combined with concomitant management of associated meniscal or chondral lesions whenever indicated. Our preference is to perform the procedure with the patient in the supine hanging leg position under spinal or general anaesthesia, using a central quadriceps tendon autograft. However, the procedure can also be performed using a single-bundle or double-bundle technique and with alternative fixation methods depending on surgeon preference and intraoperative findings. When the decision to proceed with ACL reconstruction is made preoperatively, central quadriceps tendon harvesting is performed at the beginning of the procedure; however, in cases where the final decision is based on intraoperative assessment of ligament integrity and knee stability, graft harvesting may be performed later during the surgery.

Patient Position

The patient is positioned supine on a radiolucent operating table in hanging leg position under spinal or general anesthesia. A lateral post is placed at the level of the proximal thigh used to maintain knee in flexion and valgus position whenever required . A pneumatic tourniquet is applied to the proximal thigh but inflated only after limb exsanguination. The limb is prepared and draped in standard sterile fashion.

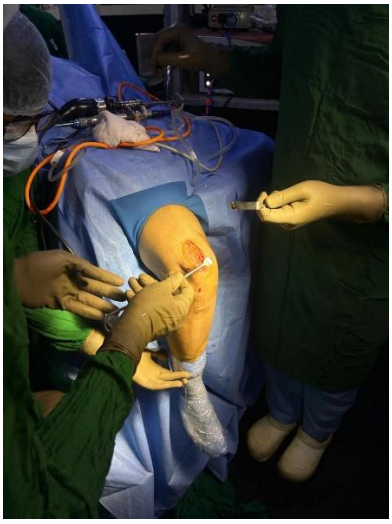


Fig.1- Hanging Leg position

Harvesting the central quadriceps tendon autograft

Graft Harvest

A double-bladed knife or scalpel is used to harvest the central third of the tendon. The graft is dissected proximally to obtain a length of approximately 7–9 cm.

The graft may be harvested as:

- All–soft tissue quadriceps tendon graft, or
- Bone–quadriceps tendon graft, where a rectangular bone block is harvested from the superior pole of the patella using an oscillating saw.

Hemostasis is achieved, and the donor site is irrigated.

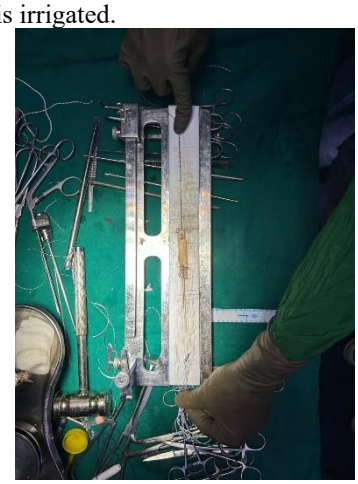


Fig.2- Graft Preparation

The common femoral tunnel preparation

The femoral tunnel is prepared using an anatomic anteromedial portal technique. The knee is flexed to 120–130° to prevent posterior wall blowout and allow accurate tunnel placement. After debridement of ACL remnants, the native femoral ACL footprint is identified using landmarks such as the resident's ridge and posterior cartilage margin.

A guide pin is placed at the center of the femoral footprint through the anteromedial portal, ensuring adequate posterior wall preservation. A cannulated reamer matching the graft diameter (usually 8–10 mm) is used to drill the femoral tunnel to a depth of 25–30 mm under direct arthroscopic visualization. Tunnel integrity and position are confirmed, and a shuttle suture is passed for graft passage.

The tibial tunnel for ACL

With the knee flexed to 90°, residual ACL fibers are debrided to expose the native tibial footprint, located anterior to the tibial spine, medial to the anterior horn of the lateral meniscus, and posterior to the intermeniscal ligament. A tibial aiming guide set at 55–60° is positioned at the center of the footprint. A guide wire is passed and confirmed arthroscopically to avoid roof impingement. Over the guide wire, a cannulated reamer matching the graft diameter (8–10 mm) is used to create the tibial tunnel. Tunnel position and smoothness are confirmed, and a shuttle suture is passed for graft passage.

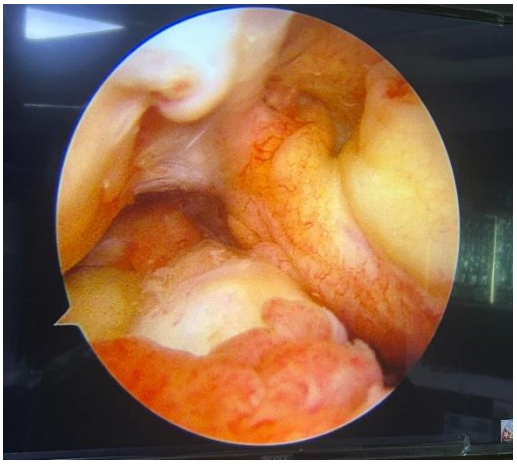


Fig.3- Intra-operative photo

Graft preparation

The harvested central quadriceps tendon graft is cleared of excess soft tissue and measured for length and diameter. The graft length is usually 7–9 cm, with a diameter of 8–10 mm. Both ends of the graft are secured using Krackow or whip-stitch sutures with high-strength non-absorbable sutures. The prepared graft is kept moist in saline until implantation.

Graft fixation

The graft is passed through the tibial tunnel into the femoral tunnel.

Femoral fixation is achieved using a suspensory fixation device or interference screw, depending on graft type. Tibial fixation is performed using an interference screw with the knee held in 20–30° of flexion under appropriate graft tension. The knee is cycled to remove graft creep before final fixation, and stability is reassessed.

Fig.4- Clinical photo

Closure

After completion of graft fixation and confirmation of knee stability, meticulous hemostasis is achieved at the quadriceps tendon harvest site. The quadriceps tendon defect is closed using interrupted absorbable sutures, ensuring approximation

without excessive tension. The paratenon is carefully repaired in a continuous or interrupted manner to restore the tendon gliding surface and minimize postoperative adhesions and anterior knee pain.

Subcutaneous tissues are closed with absorbable sutures, followed by skin closure using interrupted or subcuticular sutures as per surgeon preference. Arthroscopic portal sites are closed with absorbable sutures after thorough joint lavage and evacuation of fluid. A sterile dressing is applied over all incisions, and a compression bandage is placed to reduce postoperative swelling. A knee brace may be applied depending on the rehabilitation protocol.

REHABILITATION PROTOCOL

Phase	**Time Frame**	**Goals**	**Weight Bearing**	**ROM Goals**	**Exercises / Activities**
Phase I: Immediate Post-Op	0–2 weeks	Reduce pain & swelling, protect graft, activate quadriceps	WBAT* with crutches	0–90°	Ankle pumps, quad sets, straight leg raises, heel slides, patellar mobilization
Phase II: Early Rehab	2–6 weeks	Restore ROM, improve gait, build strength	Full WB (wean crutches)	0–120°+	Closed-chain exercises, mini-squats, leg press (light), stationary bike
Phase III: Strengthening	6–12 weeks	Increase strength & endurance, neuromuscular control	Full	Full ROM	Lunges, step-ups, hamstring curls, balance training, core strengthening
Phase IV: Advanced Strength	3–5 months	Improve power, agility, dynamic stability	Full	Full	Plyometrics, lateral movements, agility drills, single-leg strengthening
Phase V: Return to Sport Prep	5–9 months	Sport-specific training, injury prevention	Full	Full	Running progression, cutting drills, jumping/landing mechanics
Phase VI: Return to Sport	9–12 months	Safe return to competition	Full	Full	Full practice participation after functional testing clearance

CASE-1

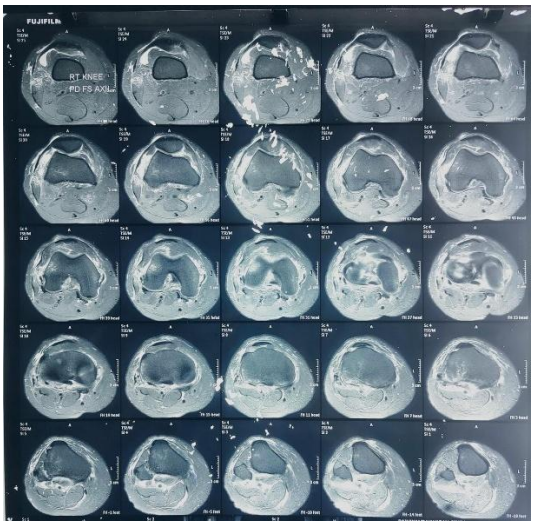


Fig.5

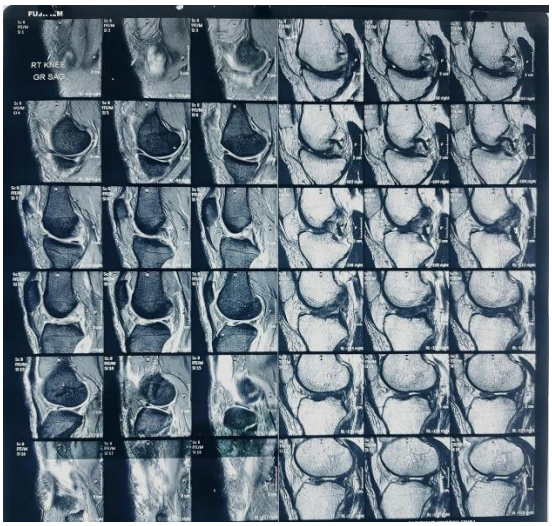


Fig. 6

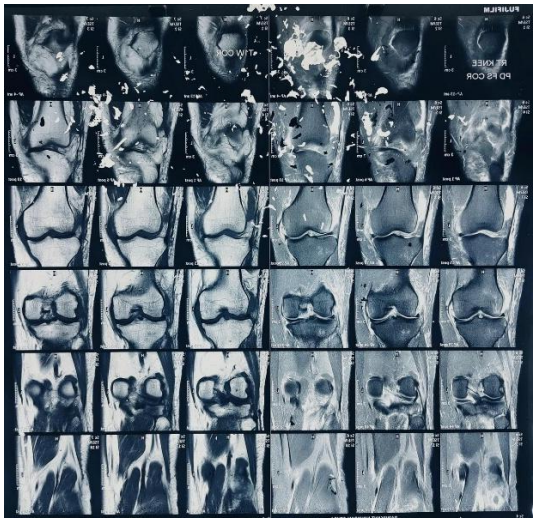


Fig. 7

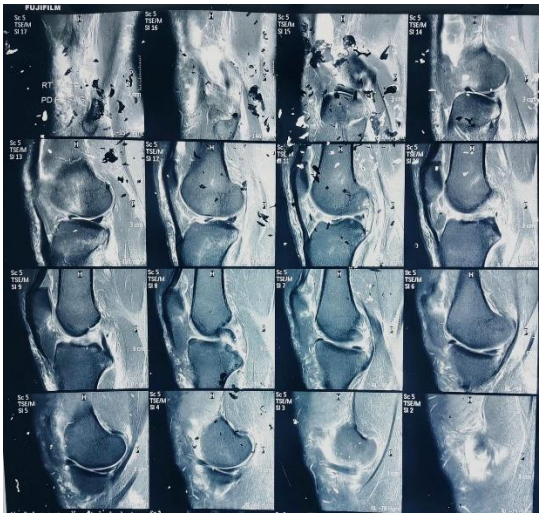
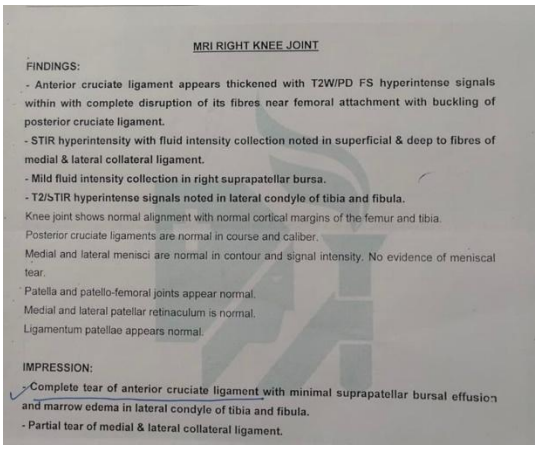


Fig.8



MRI RIGHT KNEE JOINT

FINDINGS:

- Anterior cruciate ligament appears thickened with T2W/PD FS hyperintense signals within with complete disruption of its fibres near femoral attachment with buckling of posterior cruciate ligament.
- STIR hyperintensity with fluid intensity collection noted in superficial & deep to fibres of medial & lateral collateral ligament.
- Mild fluid intensity collection in right suprapatellar bursa.
- T2/STIR hyperintense signals noted in lateral condyle of tibia and fibula.

Knee joint shows normal alignment with normal cortical margins of the femur and tibia.
Posterior cruciate ligaments are normal in course and caliber.
Medial and lateral menisci are normal in contour and signal intensity. No evidence of meniscal tear.
Patella and patello-femoral joints appear normal.
Medial and lateral patellar retinaculum is normal.
Ligamentum patellae appears normal.

IMPRESSION:

- Complete tear of anterior cruciate ligament with minimal suprapatellar bursal effusion and marrow edema in lateral condyle of tibia and fibula.
- Partial tear of medial & lateral collateral ligament.

Fig.10
PRE-OPERATIVE MRI

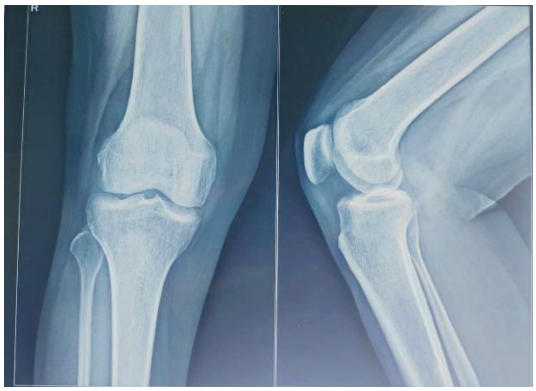


Fig.11- Pre-op Xray

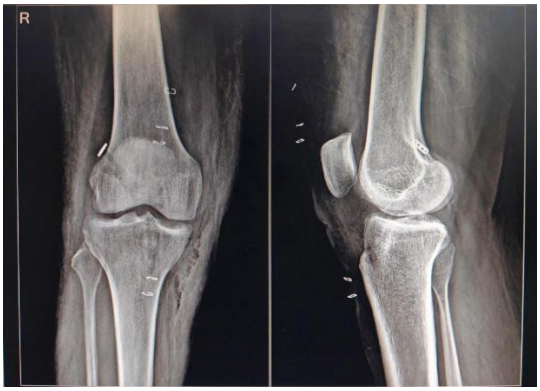


Fig.12- Post-op Xray

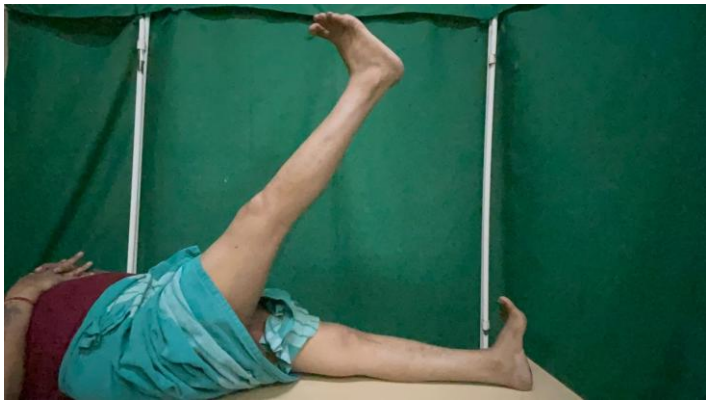


Fig.13

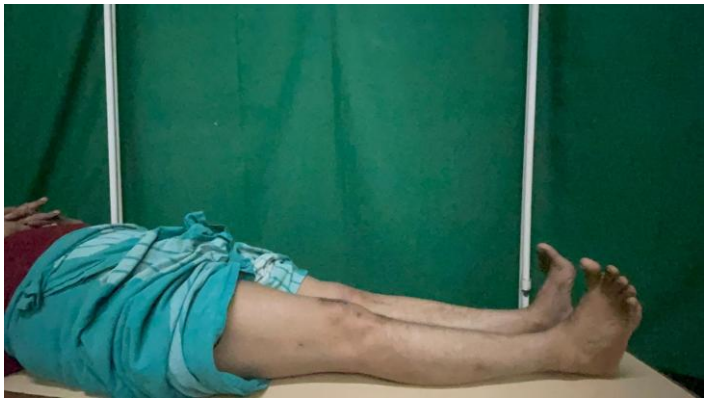


Fig.14

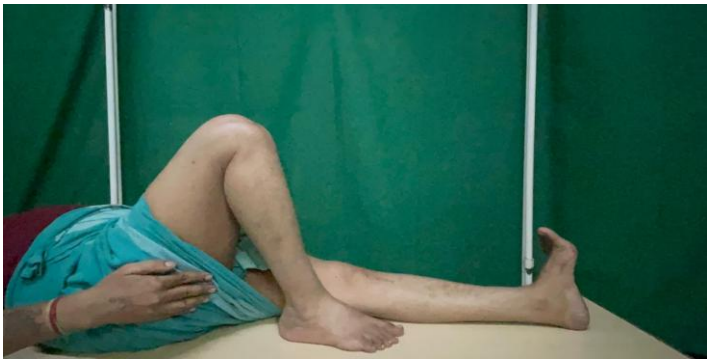


Fig.15

RESULT

The functional outcomes of anterior cruciate ligament reconstruction using central quadriceps tendon autograft are generally favourable; however, results may vary depending on factors such as patient age, activity level, graft size, surgical technique, associated injuries, and adherence to rehabilitation protocols. A summary of commonly reported outcomes is presented below:

1. Pain Relief
   Most patients experience significant reduction in knee pain following surgery. Postoperative pain typically decreases within the first few weeks, with continued improvement as graft incorporation and rehabilitation progress.
2. Improved Knee Stability and Function
   Restoration of anteroposterior and rotational knee stability is consistently achieved. Improvements in functional scores and range of motion are commonly reported. Return to daily activities is usually achieved within 3–6 months, while return to sports may take 6–9 months, depending on rehabilitation and activity demands.
3. Graft Incorporation and Integrity
   central quadriceps tendon autografts demonstrate good biological incorporation and remodeling. However hamstring autograft has reported graft failure or re-rupture rates range from approximately 5–15%, influenced by patient-related factors such as high-demand sports participation, early return to activity, and inadequate rehabilitation.
4. Patient Satisfaction
   High levels of patient satisfaction are reported following central quadriceps tendon autograft ACL reconstruction. Most patients are able to return to pre-injury levels of work and recreational activities, with many resuming sports participation.
5. Predictors of Success

- Positive Factors: Younger age, adequate graft diameter, proper tunnel placement, early supervised rehabilitation, and absence of associated ligament injuries.
- Negative Factors: Older age, high body mass index, small graft diameter, poor neuromuscular control, associated meniscal or cartilage injuries, and non-compliance with rehabilitation protocols.

6. Long-Term Outcomes
   Long-term studies show sustained knee stability and functional improvement in most patients. Although degenerative changes such as osteoarthritis may develop over time, particularly in the presence of meniscal injury, functional outcomes generally remain satisfactory.
7. Rehabilitation
   A structured and progressive rehabilitation program is critical to achieving optimal outcomes. Emphasis is placed on early range of motion, quadriceps and hamstring strengthening, proprioceptive training, and gradual return to sports-specific activities.

DISCUSSION

The central quadriceps tendon autograft has emerged as a reliable option for anterior cruciate ligament reconstruction due to its favorable functional outcomes and low donor-site morbidity. Functionally, patients demonstrate significant improvement in knee stability, with postoperative Lachman and pivot shift tests showing results comparable to bone–patellar tendon–bone and hamstring tendon grafts. Instrumented laxity measurements typically indicate minimal side-to-side differences.

CONCLUSION

The use of central quadriceps tendon autograft for ACL reconstruction allowed us to reproduce a thicker graft which showed better graft strength and resistance to failure. Small-sized thinner grafts were associated with higher failure rates that represented a major limitation in other studies harvesting a double-stranded hamstring grafts with a diameter around 7 mm . The use of a central quadriceps tendon autograft for ACL reconstruction is a safe and effective technique that provides a thick, strong graft with excellent biomechanical properties. It results in high functional outcomes, improved knee stability, and a high rate of return to pre-injury activity, while minimizing donor-site morbidity and anterior knee pain. This graft represents a reliable alternative to hamstring and patellar tendon autografts, particularly in patients where graft size or anterior knee discomfort is a concern.

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