African Journal of Biological Sciences

Functional Outcome Of Anterior Cruciate Ligament Reconstruction Using Ipsilateral Autologous Hexafold Hamstring

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Article History
Volume 6, Issue 10, 2024
Received: 22 may 2024
Accepted: 05 Jun 2024
doi:10.48047/AFJBS.6.10.2024.5542-5550

Introduction

The Anterior cruciate ligament(ACL) is the most frequently damaged ligament in the knee owing to increased incidence of Road traffic and sports injuries.ACL injuries being associated with injuries to other components such as the meniscus and articular cartilage of the knee joint causes knee instability.

The ACL has two bundles, Anteromedial Bundle(AMB) and Posterolateral Bundle (PLB)(1). The PLB originates more distally on the femur and is inserted posterior-laterally on the tibia. Studies suggested that for lower degrees of flexion, PLB tends to take up more load than AMB, and vice-versa is seen for greater flexion angles (2). In some studies, it was found that AMB exhibited a larger modulus of elasticity, ultimate tensile strength, and strain energy density than did the PLB portion (1). The mechanism of anterior cruciate ligament rupture has been linked to abrupt deceleration, pivoting (turning) from one single place, and hyperextension at the knee.ACL injury in contact sports is seen due to a blow on the knee received from the outside. Non-contact sports requiring placement of the foot and rapid body direction change are mainly associated with an ACL injury. (3)

Grafts with a diameter smaller than 8 mm are more likely to risk failure and poor clinical results. To overcome this problem, the hamstring graft has been developed by folding it over itself. The 6 strands hamstring autograft (Hexafold), which triples the semitendinosus and gracilis tendon, increases graft diameter to approximately 1-2 mm and provides a graft with a diameter of more

than 8mm (4).

The cylindrical shape matches the bone tunnel shape. The development of Sharpey-like collagen fibers at the tendon-tunnel interface is facilitated by a greater graft to the tunnel contact area, which also enhances osteointegration (5).
In order to assess the functional results of ACL reconstruction employing an ipsilateral autologous hexafold hamstring graft, we sought out to conduct this study.

Material And Method

A prospective interventional study was conducted in the department of orthopedics, Himalayan Institiute of Medical Science, Swami Rama Himalayan University, Dehradun, Uttarakhand , India, from December 2020 to March 2022 for a period of 1 year and 3 months. The study was approved by the ethical committee (SRHU/HIMS/ETHICS/2022/326) of our institution. Informed consent was obtained from all the patients who participated in the study.

Inclusion Criteria:-

ACL reconstruction utilizing ipsilateral hamstring tendon autograft was performed in all elective cases.

Exclusion Criteria:-

Cases with Skeletal immaturity, Multiple ligaments injury, or any concomitant injury to the knee as a result of which the post-operative rehabilitation procedure was altered, in a patient with Ipsilateral Hamstring graft length less than 24 cm in length as such the hexafold pattern of the constituted ACL graft cannot be achieved, previous ACL or other ligament injuries to the same or the other knee required reconstructive surgery and patients who required meniscal allograft, osteotomy, or major cartilage restoration or resurfacing procedures ipsilateral or contralateral osteoarthritis knee.

Three equal folds of each of the collected tendons were made. The ends of each fold were marked. With a non-absorbable suture, the ends of the tendons were stitched. One-third of each tendon was loaded in a suspensory device according to the marks (Endobutton). The other two strands were then threaded through the needles at the ends of each of the two strands. The other end of the tendons underwent the same process (6). Utilizing medial femoral portal for femoral tunnel drilling, an arthroscopic ACL reconstruction was carried out.An endobutton was used to cortically secure the graft's femoral end, and an interference screw was used to secure the tibial end.Preoperatively, cases were assessed for functional status using the Lysholm score, and patients were followed up at intervals of 6 weeks and 12 weeks after surgery. Lysholm scale consisting of eight questions with closed-ended responses or alternates, with a final result given nominally and ordinally with a range of scores with 95 to 100 considered "excellent" , 84 to 94 points deemed "good" , "Fair" ranged from 65 to 83 and "poor" if values were equal or below 64 points.In each instance, the same surgeon carried out the surgery. For six months, each patient followed the same postoperative rehabilitation routine.(7)

Study Tool

Structured Case Reporting Form
Radiological examination board

Lysholm Score.

MRI
Arthroscopy instruments and camera system.
ACL Reconstruction Instruments
Implants

Study Protocol

Operative Protocol
Pre-operative work

1. Information regarding the medical history, describing the cause of injury, locking or catching of knee, and description of the onset of swelling were recorded.
2. All patients were evaluated pre-operatively as per the Lysholm score (Annexure III).
3. Roentgenograms of bilateral knees were taken in antero-posterior view and lateral view in standing and lateral position respectively.
4. MRI was done on all the patients to confirm the clinical diagnosis.

Informed Consent

All of the participants in this study provided their preoperative consent for surgery. The benefits and drawbacks of the surgery were thoroughly communicated to patients and their caregivers.

Procedure

Before harvesting the graft, diagnostic arthroscopy was done. An antero-lateral port (viewing portal) was made at the level of the inferior pole of the patella just lateral to the patellar tendon.
One centimeter medial to the tibial tuberosity and 3 cm below the medial joint line marked the beginning of an oblique skin incision. The Sartorius fascia as well as Pes Anserine bursa, which protected both the hamstring tendons, were evident at the tibial tubercle level.
An incision in the sartorial fascia was used to expose the tendons. The tendons were identified and extracted individually with an open tendon stripper, released proximally from their muscle connections while bending the knee and pushing the stripper in a proximal direction.
The muscle belly pattern and harvest position of each tendon was used to identify it. The gracilis tendon has a rounded-shaped muscular belly and is placed above and proximal to the semitendinosus; the semitendinosus (ST) is located below and distal to the GC and has a U-shaped muscular belly (38).
Each hamstring autograft had excess muscle tissue removed. The grafts were examined in a graft preparation station and their diameter was measured with a measuring cylinder. The information was entered into the case reporting form.

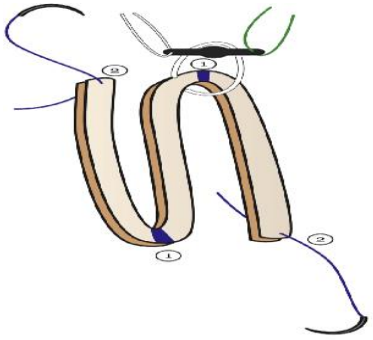

Figure 1- "Procedure for making a six-stranded graft with two tendons: The tendons were made in three equal sections(1) The folds' ends were noted. According to the marks, one-third of all tendons were put into a suspensory device (2) A non-absorbable suture was used to suture the end of both tendons. The needle was then threaded and passed through the graft's remaining four strands. The technique was then repeated with the opposite end" (38).

The ACL was arthroscopically reconstructed by constructing a femoral tunnel through the usual accessory medial femoral portal. The same procedure was utilized on all of the participants in the study.

A suspensory loop was used to anchor the graft's femoral end, and an interference screw was used to fix the graft's tibial end.

Statistical Analysis

The SPSS version 17.0 was used to assess descriptive statistics. The mean and standard deviation for continuous variables were reported. Frequencies and percentages were used to express categorical variables. To see if there was a link between two variables, Pearson's chi-square test or the chi-square test of association was utilized. A p-value of 0.05 was deemed significant.

Results

Table 1 shows the mean age of patients was 33.05±10.93 years. A total of 35 (87.5%) patients were males and 5 (12.5%) were female. 22(55%) patients sustained injury to right knee whereas 18(45%) cases sustained injury to left knee. It was observed that Road traffic accident was seen in 17 (42.5%) as a mode of injury while 12(30%) had a history of trauma. Diagnostic arthroscopy suggested that medial meniscal tear were seen in 52.5% of cases and 22.5% had lateral meniscal tear. 22.5% were isolated ACL injuries. 5 cases (12.5 %) had an osteochondral injury. There was no posterior cruciate ligament (PCL) injury in our study.

Table 1: Demographic and Clinical characteristics of the ACL injury patients (n=40)

Characteristics	N(%)or mean±SD
Male	35 (87.5%)
Female	5 (12.5%)
Age (Mean)	33.05± 10.93 years
Right-side ACL injury	22(55%)
Left side ACL injury	18(45%)
Mode Of injury	
RTA	17 (42.5%)
Trauma	12 (30%)
Sports Injury	11 (27.5%)
Types Of Injury	
ACl+Medial meniscus	21 (52.5%)
ACL+ Lateral meniscus	9 (22.5%)
Isolated ACL injury	9 (22.5%)
ACL+ Chondral injury	5 (12.5%)
Final Graft sizes	
8 mm	26 (65%)
8.5mm	9 (22.5%)
9mm	4 (10%)

9.5mm	1 (2.5%)
Mean size	8.35 mm

Table 2: Injury- surgery interval for ACL reconstruction surgery(n=40)

S No.	Time	No.of patients	Percentage
1	Under 6 weeks	5	12.5%
2	6 weeks-3 months	13	32.5%
3	3 months to 6 months	15	37.5%
4	6 months to 1 year	2	5%
5	More than 1 year	5	12.5%
	Total	40	

The majority of the patients who were operated on between 3 months – 6 months (37.5%) had a time interval from injury to surgery followed by 6 weeks- 3 months (32.5%) as shown in Table 2.

Table 3- Mean Lysholm score as pre-op and post-op at 6 and 12 weeks.

	Pre-Op	6 week (Postop)	12 week (Postop)
Excellent(>94)	0	0	2(5%)
Good(84-94)	0	3(7.5%)	27(67.5%)
Fair(65-93)	8(20%)	32(80%)	10(25%)
Poor(<65)	32(80%)	5(12.5%)	1(2.5%)
Mean + SD	55.475±11.13	73.05± 6.29	87.1± 5
P-Value	<0.0001		

Table 3 shows the trend and comparison of the mean Lysholm score from baseline to 12 weeks. It was observed that there was an increasing trend of mean Lysholm score from baseline to 12 weeks i.e. means Lysholm score at pre-Op was 55.47 ± 11.13, at 6 weeks was 73.3 ± 6.91, and at 12 weeks was 86.7 ± 4.99. Further, it was observed that there was a significant difference in the mean Lysholm score when compared from Baseline to the other two time points (p =<0.0001).

Discussion

In ACL reconstruction surgeries, for better functional outcomes, key factors playing crucial role are anatomical placement of graft, biological integration, revascularization capability, and strength and stiffness of the graft comparable to native ACL. The hexafold hamstring grafts outperform the gold standard bone-patellar tendon-bone graft in terms of cross-sectional area, strength, and stiffness(8).In our study, the short-term functional outcome of the hexafold hamstring graft harvested ipsilaterally for ACL reconstruction was analyzed.

The present study reveals that among the patients operated on, 17 (42.5%) were injured in road traffic accidents, 12 (30%) were injured as a result of trauma, and 11 (27.5%) were injured while playing or exercising. Given these facts, it is clear that ACL injuries are more frequent among physically active adults. This study is closely related to a study by Griffin et al.(9) and Davarinoset al.(10), both of which state that the anterior cruciate ligament is commonly damaged ligament amongthose who participate in sports. According to our findings, the most prevalent mechanism of injury is RTA, which was somewhat different from the rest of the studies. This significant difference in the mode of injury may be due to a less number of people participating in sports in our country than those in western countries, as well as road traffic accidents are often quite frequent in India due to poor rules and regulations compared to western countries.

In the present study, 37.5% of patients presented at 3-6 months post-trauma; 32.5% presented between 6 weeks to 3 months post-trauma; 12.5 % of patients presented before 6 weeks and after 1 year of post-trauma and 5 % of patients presented 6 months to 1-year post-trauma. The ideal timing for ACL reconstruction surgery is debatable. The meniscal tear occurs more frequently in ACL-deficient knees over time, and it has also been demonstrated that a meniscal injury increases the chances of progression of osteoarthritis in the afflicted knee. Although early ACL reconstruction decreases the risk of associated secondary meniscal tears by establishing near-to-normal knee kinematics but may not decrease the chances of developing posttraumatic Osteoarthritis.In their study, Shelbourne et al discovered that a increased risk of developing knee arthrofibrosis was associated with ACL reconstructions carried out during the first week after injury than those who had surgery after 3 weeks. It is advised to wait 6 to 8 weeks between the time of the injury and the period of the surgery to allow for recovery (swelling, effusion, erythema)(11).

In the present study, it is evident that 52.5% of patients had any grade of medial meniscus injury followed by isolated ACL injury (22.5%) and Lateral meniscal injury (22.5%).10 %of the Patients had presented with osteochondral defect at the time of presentation. In a study by Choudhary et al, Injuries to the medial meniscus occurred in 37.9% of the study population, whereas injuries to the lateral meniscus occurred in 16.7% of the patients(12).

In the present study, the author used 8mm, 8.5mm, 9mm, and 9.5mm diameter grafts from ipsilateral Hamstrings. Out of the total of 40 cases, in 26 cases 8mm graft was used; 8.5mm graft was used in 9 cases; 9mm graft was used in 4 cases and 9.5mm graft was used in a single caseA six-fold Hamstring graft with a cross-sectional size of roughly 79mm2 and occupying a greater surface area of the ACL footprint may result in improved stability as well as there will be greater surface area accessible for tendon-to-bone repair. The 6-fold graft's bigger cross-sectional area means that this graft should have a higher load before failing (13).

The Lysholm score is excellent for evaluating the knee's functional health, according to several research.The advantage of the Lysholm score for knee functional evaluation has also been supported by several earlier investigations. The Lysholm score's validity, reliability, and responsiveness were evaluated in research conducted by Jack Lysholm (14), Briggs et al (15), and others. In the present study, the Lysholm score trend from pre-injury to 12 weeks postoperative period, demonstrating a statistically significant improvement in the mean Lysholm score (p 0.0001) on follow-ups.

A comparison of the present study with several other authors was made. Laoruengthana et al. conducted a randomized clinical trial with a 6-stranded hamstring autograft of an average of 19 months.Mean diameter of the hamstring graft was 9.45mm. The mean lysholm score at 1 year of follow-up was increased from 61 to 92. They found that a bigger surface area offered superior stability, and a higher cross-section area increased the graft's final load-to-failure ratio (16).Dai et al, conducted prospective randomized controlledtrial.In the study, the clinical outcome on the bases of Lysholm score was calculated after 1 year post-op. Lysholm score among 6-strand hamstring graft rose from pre-op of 62.9 to post-op of 93.9.Hexafold graft also provided better anteroposterior and rotational stability. They concluded six-strand graft is technical feasible and achieved adequate stability (17).Jaju et al. undertook a prospective study in 2008, with 1 year of minimal follow-up. They concluded that there was an improvement in the lysholm score and better stability in 6 strand hamstring graft with a diameter of more than 8 mm(18).The present study also shows significant improvements (p=<0.0001) with a hexafold hamstring graft with a mean Lysholm score of 87.1 at the 12th-week follow-up with an average graft diameter of 8.35 mm.

Following an ACL reconstruction, short-term complications can include infection and a decrease in knee strength and mobility, while long-term concerns can include additional ACL injuries to the affected or contralateral knee and a subsequent inability to participate in high-level sports(19). There were no noteworthy complications in our trial. The majority reported chronic dull anterior knee discomfort and sporadic edema. This might be because of irregular follow-up or could be due to the aggressive rehabilitation program of each patient. There were some complaints regarding pain in the knee while descending downstairs, pain on full flexion or squatting, and some residual stiffness due to poor compliance with physiotherapy. There were no incidence of graft ruptures, infection, deep vein thrombosis or pulmonary embolism associated.

Table 4 – Result comparison of other studies with the present study

Study	Sample size	Lysholm score	Time	Graft type	Mean graft diameter
Laoruengthana et al(16)	13	92.08	1 year	6HT	9.54 mm
Dai et al(17)	61	93.9	1 year	6HT	9.35mm
Jaju et al(18)	78	88.17	1.5 year	6HT	9.73mm
Our study	40	87.1	12 weeks	6 HT	8.35 mm

Table 4 shows the result of other studies and their comparison with the present study.A 6-fold (hexafold) hamstring autograft graft with an average diameter of more than 8 mm was used in each study. Results show significant improvements in Lysholm scores postop attributing to better knee stability, higher load-to-failure ratio, and better functional outcomes. Our study shows similar results.

Conclusion(s)

This study analysedthe short-term functional outcomes in 40 individuals who had ACL reconstruction using an ipsilateral hexafold hamstring graft with a final graft diameter of 8 mm and more. The functional outcome was assessed as per Lysholm scoring preoperatively and were followed up for 6 and 12 weeks duration after surgery.

When the functional outcome was statistically analyzed, it was found that the Lysholm score considerably increased with each subsequent follow-up, demonstrating the efficacy of the procedure and the patient's better condition.

Limitation(s)

Following are the limitation associated with our investigation. First off, a follow-up of 12 weeks is considered short-term. To examine the long-term effects of ACL reconstruction using ipsilateral hexafold hamstring autograft, longer follow-up is required. Secondly, a larger influence on our results would need a larger sample size than we currently have. Thirdly, other causes of failure could not be controlled such as tunnel malposition as tunnel location cannot be assessed in all patients. Lastly lack of scoring for Activities of Daily Living as well as time to return to sports. When evaluating the findings of this study, these important limitations should be considered. More research is needed to validate and explain these findings.

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