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ORIGINAL RESEARCH

Comparison between Functional Outcomes of Quadriceps Tendon versus Hamstring Tendon Autograft for Primary Anterior Cruciate Ligament Reconstruction

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ABSTRACT

Background: Anterior cruciate ligament (ACL) injuries are common injuries in athletes, and, accordingly, ACL reconstruction (ACLR) is one of the most common orthopedic surgical procedures performed on athletes. Arthroscopic reconstruction of the injured ACL has become the gold standard. Open reconstruction of ACL, which was done earlier, is not practiced nowadays due to the complications associated such as increased post op pain, stiffness, and a lengthy rehabilitation phase. **Aim and objective:** To compare the functional outcomes of quadriceps tendon versus hamstring tendon autografts for primary ACL reconstruction.**Material and Method:** This a prospective study conducted in NC Medical College and Hospital, Israna, Panipat, Haryana. 60 patients were included in the study and randomised into two groups: one group was operated with a quadriceps tendon graft, and the other group used a hamstring tendon autograft. Both groups underwent surgery using suspensory fixation, and postoperative rehabilitation was similar. Functional outcomes (assessed using Lysholm and International Knee Documentation Committee (IKDC) scores), return to preinjury activity, and complications were evaluated. The student t- test was applied to compare pre- and postoperative functional outcomes (Lysholm and IKDC scores) at 6, 12, and 24 months, with a significance level of $p<0.05$. **Results:** Out of 60 patients, 40 (66.7%) were male and 20 (33.3%) were female. The follow-up period ranged from a minimum of 24 months to a maximum of 26 months. The mean Lysholm score in the hamstring group increased from 46 preoperatively to 93 at six months postoperatively, while in the quadriceps group, it increased from 45 preoperatively to 91 at six months postoperatively. The reliability and validity of the IKDC score for the hamstring group also increased from 47 preoperatively to 88 at six months, and for the quadriceps group, it increased from 45 preoperatively to 87 at six months. A total 55 of the cases (91.7%) returned to their preinjury activity, while 5 patients (8.3%) (3 from the hamstring group and 2 from the quadriceps group) experienced knee stiffness, which restricted their ability to squat and sit cross-legged. There were no significant differences in Lysholm and IKDC scores between the hamstring and quadriceps tendon autografts at 6, 12, and 24 months postoperatively. **Conclusion:** Patients undergoing single bundle ACL reconstruction have comparablefunctional outcomes with either hamstring or quadriceps grafts at the end of the 2-year follow-up period, with no specific graft site complications. The soft tissue quadriceps tendon autograft can be considered as an equally viable option for graft selection.

Key words: Anterior cruciate ligament injuries, Autografts, Arthroscopy, Lysholm knee score

INTRODUCTION

The outcomes after anterior cruciate ligament reconstruction (ACLR) are less than ideal, with fewer people returning to sport (RTS) [1] and even less returning to performance [2]. A particular concern after ACLR is the high rate of ACL and knee re-injuries after RTS, particularly amongst young athletes (~30%) [3]. RTS after injury is a complex, multifactorial process and requires a biopsychosocial approach [4]. Current opinion is that if we are to optimize patient outcomes, then we need to optimize our rehabilitation approach. There is, however, no consensus on rehabilitation after ACLR, despite considerable effort in recent years to clarify and

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optimize the process [5]. One issue in clinical practice is the large disconnect between research and practice, thought to be due to ineffective implementation of evidence-based findings [6]. It is also well recognized that if we are to truly impact individual patients, a stronger focus on research implementation is needed to translate efficacious rehabilitative and preventive methods into practice [7].

One important piece of the complex puzzle of ACL rehabilitation is restoring knee flexor muscle function. The hamstring muscles are vitally important for the knee. During forceful dynamic movements, coactivation of the hamstrings is important to provide dynamic knee joint stabilization and to prevent excessive ACL shear forces [8]. Thus, the hamstring muscles are considered ACL-agonists. ACL injury, the resultant surgery, and reduced functionality after surgery significantly impact hamstring function, with deficits of nearly 50% reported at 4 weeks after ACLR with hamstring tendon autograft (HG) [9]. Restoring hamstring function is a key aspect of the functional recovery process after ACLR [10]. Unfortunately, deficits in knee flexor strength can be high at the time of RTS (0-20%) [11] and even for many years after ACLR [12]. Although deficits in knee flexor strength are typically less than that for the knee extensors [13], even small deficits in knee flexor strength can be detrimental to injury risk upon RTS. In particular, within a group of professional football players, Kyritsis et al. [14] reported a 10.6-fold increased risk of ACL re-injury upon RTS for each additional 10% deficit in knee flexor to extensor ratio. Furthermore, a history of severe knee injury (including ACL injury) increases the risk of a future hamstring strain injury (HSI) [15]. Although there are multiple risk factors for HSIs, likely all interrelating in a complex manner [16], including previous hamstring history [17], age [18], hamstring muscle architecture [19], lumbo-pelvic hip stability [34, 44-48], and training load [20], amongst others, the increased risk of HSI after severe knee injury is likely in part due to the altered hamstring strength function. After HSI, those athletes re-injured upon RTS were ~14% weaker in hamstring strength recovery after ACL reconstruction compared to those that remained injury-free when assessed prospectively [21]. So, assessing and treating knee flexor strength is a major element of the ACL functional recovery process [10].

The hamstring muscles are responsible for more than just knee flexion, contributing to hip extension, as well as knee and pelvis stability. In particular, the medial hamstrings are thought to be important for preventing ACL injuries, due to their role in preventing medial condyle lift-off and dynamic knee valgus [22], a known ACL injury risk factor [23]. Of particular relevance after ACLR with HG is the commonly observed deficit in knee internal rotation strength weakness [24], which would be expected to contribute to the increased external tibial rotation and dynamic knee valgus found in ACLR patients [25]. Muscle architectural changes can also occur independent of muscle size, and the BicepsFemoris long head (BFLH) of the ACLR limb has been shown to demonstrate shorter muscle fascicles and greater pennation angles after ACLR with HG [26]. The architectural changes in BFLH are comparable to the changes observed in those with previously HSI of BFLH [27]. Recent evidence suggests that professional soccer players with shorter BFLH fascicles (<10.56 cm) were four times more likely to sustain a future HSI than those with longer fascicles, and that the probability of injury was reduced by around 20% for every 1 cm increase in fascicle length [28]. It has been hypothesized that possessing shorter muscle fascicles, with fewer in-series sarcomeres, may result in an increased susceptibility to eccentrically induced muscle damage [29], which may predispose the athlete to increased running-related HSI.The knee joint is one of the body's most complicated joint. There is an increase in the occurrence of knee ligament injuries due to the ever-increasing road traffic accidents and increased involvement in sports activities. Knee joint has proximal femur bonedistally tibia and fibula bone with ligaments and capsules, meniscus, and bursa. Important ligaments are Anterior cruciate ligament (ACL), Posterior cruciate Ligament (PCL), Medial collateral Ligament (MCL), Lateral collateral Ligament (LCL). The ACL together with other ligaments, capsule is the primary knee stabilizer and prevents anterior translation, and limits valgus and rotational stress to some extent.

In recent years, the soft tissue quadriceps tendon has been increasingly used as a graft choice for ACL reconstruction due to its reliable graft size. The Quadriceps tendon has the same width as the patellar tendon but a larger cross-sectional area, resistance to rupture, and can be harvested with a minimally invasive technique. It also has the ability to adjust in width as per the intraoperative requirement [30]. Compared to the hamstring graft, it exhibits less laxity on pivot shift, and therefore lower failure rates compared to the hamstring graft have been claimed [31]. However, some reported disadvantages include the need for an extra incision for graft harvest, which can lead to Quadriceps atrophy and weakness postoperatively, and in rare cases (<1%), donor site quadriceps tendon rupture [32].

Studies claim that the Quadriceps tendon as a graft tends to perform better or equally to the hamstring tendon in terms of functional outcomes and has fewer complications [31]. The available literature comparing quadriceps and hamstring grafts in ACL reconstruction is limited. Hence, the present study aimed to compare the functional outcomes of these autografts using suspensory fixation at the femoral and tibial sites,excellent (91-100) to unsatisfactory (<65) [33]. The IKDC scoring system assessed subjective assessment, symptoms, range of motion, and ligament inspection, with scores ranging from 0

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(lowest level of function or highest level of symptoms) to 100 (highest level of function and lowest level of symptoms) [34]

The signs of knee instability, discomfort, and a decrease in joint function arise when an ACL injury occurs. Even though patients with less expected knee scores can be treated with conservative treatment with intensive physiotherapy, bracing, and lifestyle modification, ACL reconstruction is necessary in symptomatic young active individuals. Also, ACL injuries are mostly associated with injury of the meniscus, which can be addressed; else, a person can develop early onset of osteoarthritis of the knee [35-36].

MATERIALS AND METHODS

A randomised controlled study was conducted at Department of Orthopaedics, NC Medical College and Hospital, Israna, Panipat, Haryana. India.

Inclusion criteria: The study included patients aged 18 to 45 years with clinically and Magnetic Resonance Imaging (MRI)-confirmed ACL ruptures.

Exclusion criteria: Patients with ACL ruptures associated with meniscal injury requiring meniscectomy, multiligament knee injuries, open knee injuries, associated fractures around the knee joint, associated neurovascular injury, polytrauma, and patients medically unfit for surgery were excluded.

Procedure

A total of 68 patients were initially recruited, but eight patients did not meet the inclusion criteria, resulting in a final sample size of 60 patients. The subjects were randomised into two groups using the lottery method. Group A (30 patients) underwent ACL reconstruction using the quadriceps tendon, while Group B (30 patients) underwent ACL reconstruction using the Hamstrings tendon autograft. Both
groups underwent ACL reconstruction with suspensory fixation on both the femoral and tibial sides. The postoperative rehabilitation protocol was the same for both groups. Patient demographics, side of the injury, functional outcomes (measured by Lysholm [32] and IKDC [33] scores), return to preinjury activity, and complications were assessed. Follow-up evaluations were conducted for a minimum of 12 months and a maximum of 24 months. The Lysholm and IKDC scores were assessed preoperatively and postoperatively at 6, 12, and 24 months. The Lysholm scoring system evaluated patients' perceptions of their own function and indications of instability, with scores ranging fromexcellent (91-100) to unsatisfactory (<65) [15]. The IKDC scoring system assessed subjective assessment, symptoms, range of motion, and ligament inspection, with scores ranging from 0 (lowest level of function or highest level of symptoms) to 100 (highest level of function and lowest level of symptoms) [16].

Surgical technique

(a) Graft harvest:

- For the hamstrings tendon autograft [Table/Fig-1a,b,2] [37], an oblique incision was made one finger breadth medial to the tibial tuberosity. The Sartorius fascia was incised, and the insertions of the gracilis and semitendinosus tendons were identified. Bands connecting the tendons were severed, and both tendons were stripped using a tendon stripper.
- For the soft tissue quadriceps tendon autograft [Table/ Fig-3a,b] [38], a mid-line incision ending at the superior pole of the patella was made. The anterior surface of the central portion of the quadriceps tendon was incised using a knife. The distal graft diameter would increase by 0.5 to 1 mm to prepare the graft for suture. A number 15-blade was used to extend the longitudinal incisiondistally to the superior pole of the patella. Deep dissection was avoided since only a partial thickness graft was to be harvested. After elevating 3 cm of the tendon, it was whip-stitched using a looped suture. For most patients undergoing anatomic ACL restoration, a graft length of 7 cm was sufficient [39].

(b) ACL reconstruction:

A five-strand hamstrings graft and quadriceps graft were harvested with a diameter of 9 mm in all cases. Anatomical ACL reconstruction was performed by fixing the endobutton on the femoral side and the base plate on the tibial side.[40]

The postoperative protocol and rehabilitation [40] were similar in both groups, including quadriceps strengthening, active Range of Motion (ROM) of 0-90 degrees, weight bearing as tolerated with crutches in the first two weeks, patella mobilization and ankle pumps. At four weeks, ROM of 0-120 degrees with full weight bearing using a stick was achieved. Full ROM (>130 degrees) and weight bearing without support were advised at six weeks. Further hamstrings strengthening, agility training, and sports-specific exercises were performed.

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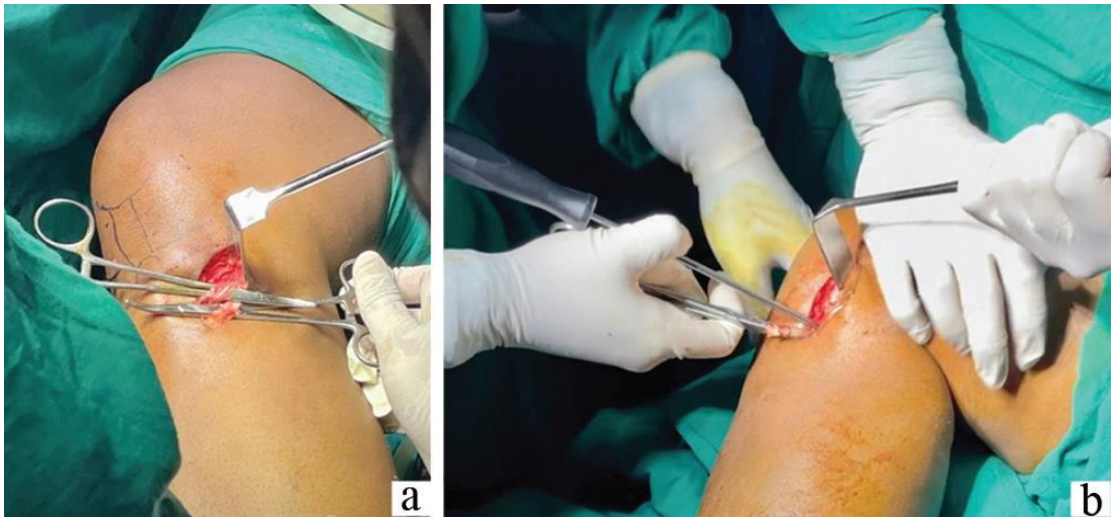

Figure no.1: Hamstrings graft harvest incision, Tendon Exposure (a); and Tendon stripping (b).

Figure no.2: Hamstrings graft preparation.

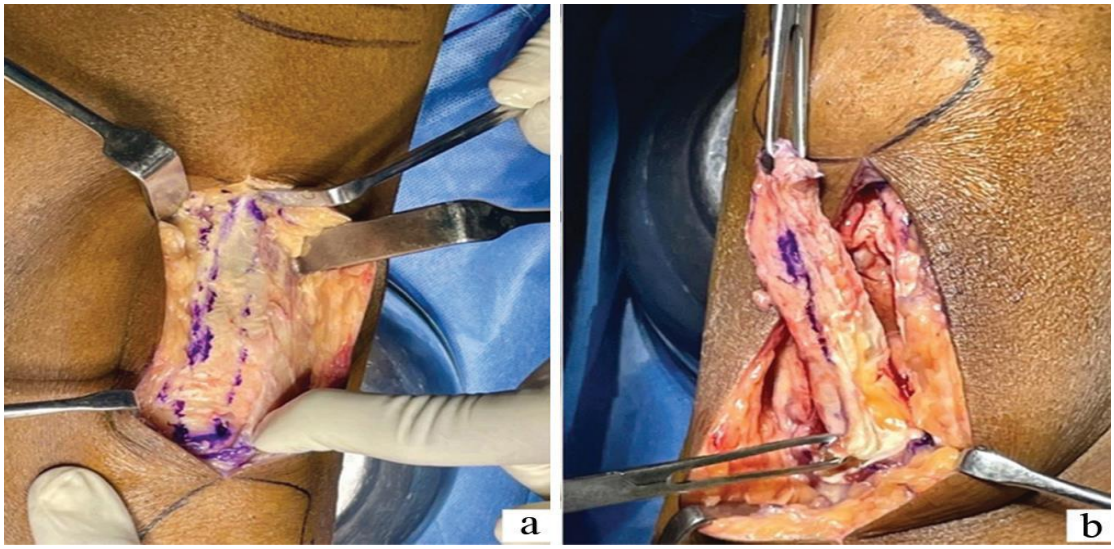

Figure no.3: Soft tissue quadriceps tendon autograft incision (a); and harvesting (b).

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STATISTICAL ANALYSIS

The statistical analysis was conducted using the Statistical Package for Social Sciences (SPSS version 24.0). The Mann-Whitney U test was applied to compare functional outcomes (Lysholm and IKDC scores) preoperatively and postoperatively at 6, 12, and 24 months. A p-value <0.05 was considered statistically significant.

OBSERVATION AND RESULTS

60 cases of arthroscopic ACL reconstruction were regularly followed for an average period of 17.6 months in NC Medical College and Hospital, Israna, Panipat, Haryana. Most of the patients (36.7%) were in the age group of 20 to 25 years followed by 26.7% in the age group of 26 to 30 years (Table 1).

Table 1: Age distribution

Age(years)	Patients	Percentage
20-25	22	36.7
26-30	16	26.7
31-35	14	23.3
36-40	8	13.3
Total	60	100

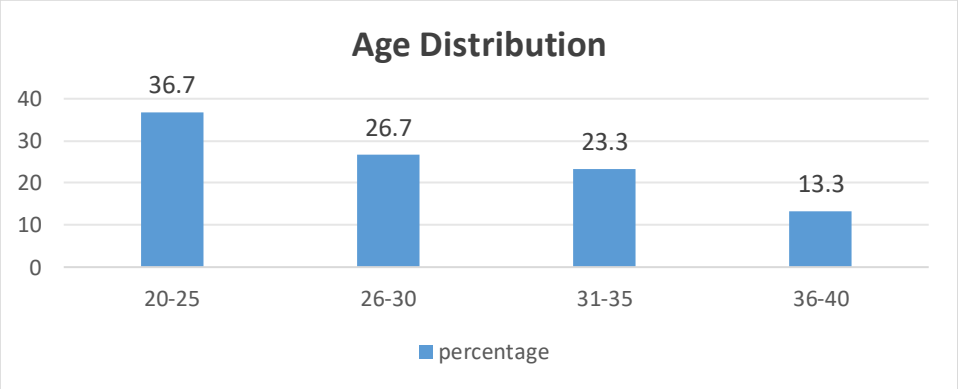

Figure 4: Age distribution.

Of the 60 patients included in our study, 40 (66.7%) were Male patients and 20 (33.3%) were female (Table 2 and Figure 6)

Table 2: Sex distribution

Gender	Numbers of patients	Percentage
Male	40	66.7
Female	20	33.3
Total	60	100

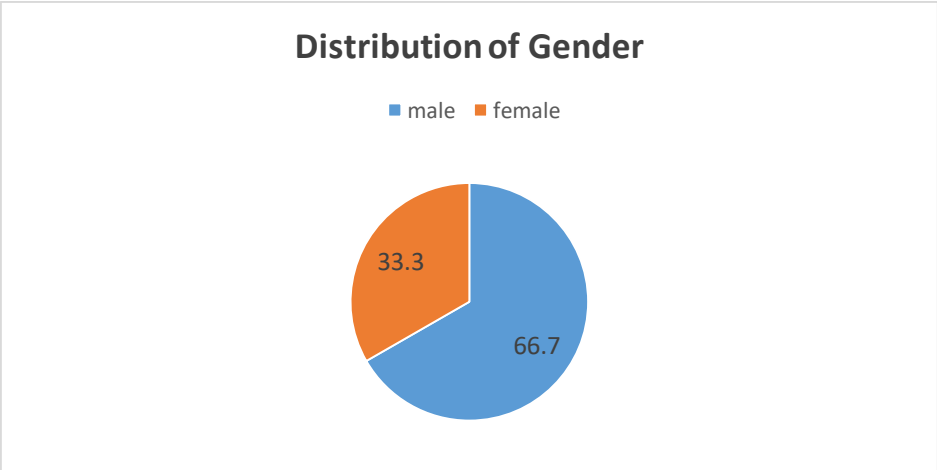

Figure 5: Distribution of gender.

In this study, the right side was more commonly injured (68.3%) than the left side (31.7%) (Table 3 and Figure 7).

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Table 3: Side involvement.

Sides	Numbers of patients	Percentage
Right	41	68.3
Left	19	31.7
Total	60	100

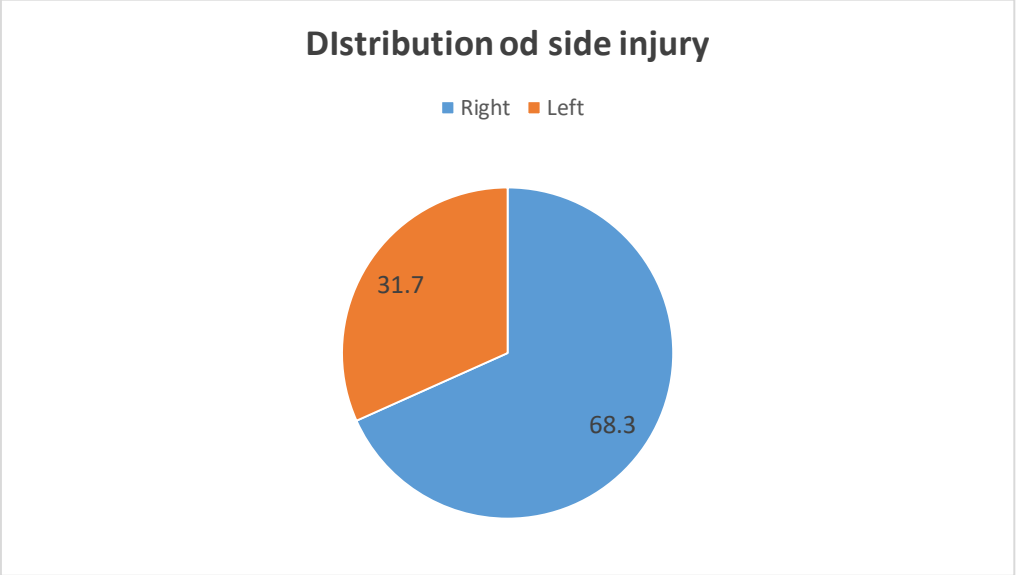

Figure 6: Distribution of side of injury.

The most common mode of injury in our study was Road traffic Accidents (50%) followed by Self fall(16.7%) and sports injuries (16.7%), fall from height (10%), kick by bull(6.7%) (Table 4)

Table 4: Mode of Injury

Mode of injury	Distribution of mode of injury	Percentage (%)
Fall from height	6	10
Others-kick by bull	4	6.7
Rta	30	50
Self-fall	10	16.7
Sports	10	16.7
Total	60	100

Table 5: Comparison of mean Lysholm scores between Hamstrings and Quadriceps tendon autograft groups preoperatively and postoperatively at 6, 12 and 24 months.

Comparison of Lysholm	Hamstrings (mean±SD)	Quadriceps (mean±SD)	P-value
Preop	47.93±5.47	45.9±5.7	0.567
Postop 6 months	88.7±7.6	87.9±7.1	0.435
Postop 12 months	92.3±6.4	90.3±7.9	0.561
Postop 24 months	93.2±5.9	94±6.4	0.168

Table 6: Comparison of mean IKDC scores between Hamstrings and Quadriceps tendon autograft groups preoperatively and postoperatively at 6, 12 and 24 months.

Comparison of IKDC scores	Hamstrings (mean±SD)	Quadriceps (mean±SD)	P-value
Preop	46.4±6.4	45.5±5.2	0.536
Postop 6 months	81.2±10	79.7±9.5	0.374
Postop 12 months	87.9±9.2	85.9±8.5	0.591
Postop 24 months	91.1±6.6	91.3±6.6	0.143

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DISCUSSION

Out of 60 patients, 30 (50%) underwent surgery with Hamstrings tendon autografts, while the remaining 30 had quadriceps tendon autografts. Among them, 40 (66.7%)were male and 20 (33.3%) were female. A total of 41 patients (68.3%) sustained a left-sided injury, while 19(31.7%) sustained a right-sided knee injury. The mean valueof the Lysholm score in the Hamstrings group preoperatively was 47.93, which increased to 88.7 at six months postoperatively and 98.8 at 24 months. The IKDC score of the Hamstrings group also increased from 46.4 preoperatively to 81.2 at six months and 91.1 at 24 months. In the quadriceps group, the mean value of the Lysholm score preoperatively was 45.9, which increased to 87.9 at six months postoperatively and 94 at 24 months. The IKDC score of the Quadriceps group also increased from 45.9 preoperatively to 79.7 at six months and 91.3 at 24 months. The Lysholm and IKDC scores for the Hamstrings and Quadriceps tendon autografts showed no significant difference ($p>0.05$) at 6, 12, and 24 months postoperatively [Table: 5-6].

All patients in the study had unsatisfactory outcomes preoperatively with a mean Lysholm score of 46.4. At six months postoperatively, 35 (58.33%) patients achieved excellent outcomes, 23 (38.3%) had good outcomes, and 2 (3.3%) patient had fair functional outcomes. At the one-year follow-up, all patients achieved excellent outcomes except for one with good functional outcomes. At the two-year follow-up, all patients scored excellent. A total of 55 (91.7%) cases returned to their preinjury activity. Three patients (three from the Hamstrings group and 2 from the Quadriceps group) still experienced knee stiffness, which restricted them from squatting and sitting cross-legged. 28 patients (46.7%) out of 60 returned to sports activity [Fig-7,8], while the remaining 32 (53.3%) experienced mild pain and difficulty in cutting, accelerating, and sudden stops while running.

Complications

One patient from each group (Hamstrings and Quadriceps) had a superficial infection at the donor site, which was treated with intravenous antibiotics. Two patients from the Hamstrings group and one from the Quadriceps group complained of knee stiffness due to poor compliance with postoperative rehabilitation. Aggressive physiotherapy helped increase the range of movement from 10 to 80 degrees. Two patients, both from the Hamstrings group, reported numbness over the anteromedial aspect of the leg. None of the patients experienced severe early postoperative pain, unsatisfactory cosmetic appearance of thepostoperative scar, implant or fixation failure requiring removal, or infection debridement.

A randomised controlled study was conducted to compare the functional outcomes of Quadriceps and Hamstrings tendon autografts in ACL reconstructions. No significant difference was observed between the two groups at a two-year follow-up. Out of 60 patients, 30 (50%) were operated on with the Hamstrings tendon, and the remaining 30 with Quadriceps tendon autograft. All patients in the study had unsatisfactory outcomes preoperatively (according to Lysholm scores). At six months postoperatively, 35 patients achieved excellent, 23 good, and 2 patient fair functional outcomes. At the one-year follow-up, all patients achieved excellent outcomes except for one with good functional outcomes. At the two-year follow-up, all patients scored excellent.

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Figure no.7: Reconstruction with four-tailed Hamstrings graft: (a) Preop T2- weighted MRI showing increased signal at femoral attachment site and disruption in continuity of ACL fibres in intercondylar notch suggestive of ACL tear; (b) Postoperative X-ray showing Endobutton at femoral site and tibial base plate in tibial site; (c) Clinical pictures at two years follow-up showing complete range of movement and quadriceps strength achieved.

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Figure no.8: Reconstruction with a soft tissue Quadriceps autograft: (a) Preop T2 weighted MRI showing increased signal at femoral attachment site and absence of ACL fibres in intercondylar notch suggestive of ACL tear; (b) Postoperative X-ray showing endobutton at femoral site and tibial base plate in tibial site; (c) Clinical pictures at two years follow-up showing complete range of movement and quadriceps strength achieved.

A similar study by Todor A et al., retrospectively followed-up with 72 patients (39 Quadriceps and 33 Hamstrings) for two years [41]. Pomenta Bastidas MV et al., conducted a non-randomised comparative study including 52 patients (25 Quadriceps and 27 Hamstrings) with a minimum two-year follow-up [42]. All patients who sustained sports-related injuries decided not to return to sports at the final follow-up. There was no significant difference in functional outcomes between Quadriceps and Hamstrings tendon autograft at the two-year follow-up based on Lysholm scores in the present study. These findings were similar to the study by Todor A et al., which also concluded no significant difference in functional outcomes based on Lysholm scores (p=0.299) [41]. Pomenta Bastidas MV et al., found no significant difference in IKDC scores (p=0.38) between both groups [42].

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In the present study, two patients from each group were noted to have a superficial infection at the donor site. Three patients (two Hamstrings and one Quadriceps group) complained of restricted range of movement due to poor compliance with postoperative rehabilitation. Two patients from the Hamstrings group reported numbness over the anteromedial aspect of the leg. None of the patients reported unsatisfactory cosmetic appearance of the postoperative scar. There were no cases of fixation failure at the tibial or femoral site at the end of two years, and no deep infections requiring debridement. Additionally, there were no implant or graft related long-term complications requiring revision. Todor A et al., reported five patients in the Quadriceps group with unsatisfactory results, while eight patients in the Hamstrings group reported mild numbness on the anteromedial aspect of the leg. None of their patients required revisions or re-operations [41]. Pomenta Bastidas MV et al., found three patients requiring revision surgery, one from the Quadriceps group due to donor site infection, and the other two (one from each group) due to sports injury [42]. Hence, the findings of the present study were similar to other studies, which concluded that the soft tissue Quadriceps tendon provides comparable outcomes to Hamstrings tendon autograft in ACL reconstruction [41-42].

CONCLUSION

Patients undergoing single-bundle ACL reconstruction have comparable functional outcomes with either hamstrings or quadriceps grafts at the end of a 2-year follow-up, with no specific graft site complications. Hence, the soft tissue quadriceps autograft can be considered a reliable graft option for primary ACL reconstruction, similar to Hamstrings, in the future.

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CONFLICT OF INTEREST: The authors declare no conflict of interest.

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