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Dr. Altaf Ahmad Kawoosa
Professor, Department of Orthopaedics, Govt. Medical College, Srinagar, Jammu and Kashmir, India

Dr. Ibreez Rakshan
Senior Resident, Department of Orthopaedics, Govt. Medical College, Srinagar, Jammu and Kashmir, India

Dr. Jawahar Mehmood Khan
Lecturer, Department of Orthopaedics, Govt. Medical College, Srinagar, Jammu and Kashmir, India

Corresponding Author:
Dr. Jawahar Mehmood Khan
Lecturer, Department of Orthopaedics, Govt. Medical College, Srinagar, Jammu and Kashmir, India

A retrospective comparative study of arthroscopic anatomical single bundle ACL reconstruction using tibial insertion preservation hamstring graft versus detached hamstring grafts

Dr. Altaf Ahmad Kawoosa, Dr. Ibreez Rakshan and Dr. Jawahar Mehmood Khan

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Abstract
Objectives: This study aimed to compare the clinical and MRI results of anterior cruciate ligament (ACL) reconstruction with tibial attachment preserving hamstring grafts (HG) against the conventional ACL reconstruction using the detached HG.
Methods: This retrospective comparative study was conducted on patients who underwent arthroscopic single bundle anatomical ACL reconstruction. The functional assessment and return to sports activities was evaluated by pre- and postoperative Lysholm score and Tegner activity score in group I (detached Hamstrings autograft) and in group II (reconstruction was performed using attachment sparing hamstring graft). The radiological evaluation was performed by the MRI (1.5-tesla whole-body scanner) performed at 1-year post-reconstruction. P-Value < 0.05 was considered as significant.
Results: In Groups I and II, Lachman test postoperatively improved to grade 0 in 76% and 90% patients, respectively (p<0.0001). The mean improvement in the Lysholm score was significantly higher in Group II as compared to Group I (32.467 vs. 28.440, p<.0001). In Group I, the mean Tegner activity score improved from 2±0.71 (pre-operatively) to 3.52±0.65 (post-operatively), p<0.0001 and in Group II, it improved from 2±0.64 (pre-operatively) to 5.2±1.03 (post-operatively), p<0.0001. Graft ligamentization was better in Group II as compared to Group I (p<0.0001) with 70% cases having Figueroa score 5 as compared to 24% in Group I.
Conclusion: In conclusion, preservation of HG tibial insertion provides a better functional recovery, graft ligamentization and graft integration in cases with ACL reconstruction.

Keywords: Anterior cruciate ligament, hamstring grafts, ligamentization

Introduction
Anterior cruciate ligament (ACL) injuries are common following road traffic accidents and sports injuries. Their reconstructions are common orthopaedic surgical procedures performed by using hamstring grafts (HG) with the primary goal of achieving knee stability and functional integrity [1].
The use of HG came into use for ACL reconstruction because they are auricular muscle groups providing good stability in knee injuries [2]. Medical advancements have confirmed the superiority of "Single-bundle anatomic ACL reconstruction" over the transtibial technique (TT) as it provides better knee kinetics [3].
However, the present concern in the use of HG remains in the preservation of its tibial attachment while reconstructing the ACL tear.
It is well established that the implantation of HG is followed by the process of ''Ligamentization" which causes it to attain ACL-like structure [4-6]. The sparing of the tibial insertion of HG may allow for a better blood supply and healing of the graft in comparison to the cases where the insertion is sacrificed [7, 8].
However, barring few reports in the literature supporting the maintenance of tibial insertion of HG, concrete reviews and clinical trials are sparse.

A recent topic review failed to definitively state the superiority of sparing of HG tibial insertion in ACL reconstruction mainly because of the limitation of assessment of graft "Ligamentization" in the postoperative period [1, 7, 9].
The use of biopsy and arthroscopic procedures for the assessment of Ligamentization is limited by ethical issues. Thus, MRI is left as one of the only modalities for evaluating the outcome of ACL reconstruction with HG. The MRI score suggested by Figueroa *et al* [10] for the evaluation of graft morphology is popular and applied in a few studies [11]. In addition to this, the Howell score is also a popular assessment method [12].
The present study was conducted to compare the clinical and MRI results of ACL reconstruction with tibial attachment preserving HG against the conventional ACL reconstruction using the detached HG.

Methods

The present retrospective comparative study was conducted in a tertiary care government hospital of North India over a period of 2 years (December 2018- December 2020) on patients (aged > 18 years) undergoing arthroscopic single bundle anatomical ACL reconstruction for ACL tears with functional instability or ACL rupture associated with meniscal tears and/or grade 1 collateral ligament tears. Any patient with a history of previous ACL injury, knee fractures, ACL injuries with > 1-grade collateral ligament tears, ligament injury to the contralateral knee, knee osteoarthritis, ACL tear with posterior cruciate ligament tear, and conditions in which knee arthroscopy is impossible, or risky such as ankylosis around the joint, knee deformities, and unfavourable local skin, were excluded from the study. Institutional ethics committee approval was obtained before the start of the study.
The sample size calculation for the index study was based on the pilot study, where the post-op Lysholm score and Tegner activity score in group I (detached Hamstrings auto-graft) was 88.4±10.43 and 3.4±0.5477 respectively and in group II (reconstruction was performed using attachment sparing hamstring graft) was 96.8±2.683 and 5.4±1.673 respectively. Taking these values as a reference, the minimum required sample size with 95% power of study and 5% level of significance was 22 patients in each study group. To reduce the margin of error, the total sample size taken was 55 (25 patients in group I and 30 patients in group II).
The demographic and clinical details of the enrolled patients were recorded after written informed consent.

Surgical techniques

The preliminary evaluation of the joints was performed arthroscopically by anteromedial and anterolateral (AL) portals under peripheral or general anaesthesia. The ACL lesion was assessed and confirmed following which the ACL remnants were debrided.

Group I: ACL reconstruction by detached HG tibial attachment [11, 13, 14]

The semitendinosus (ST) tendon was harvested without preserving its tibial insertion. The ST tendon was quadrupled, loaded with cortical suspensory devices and sutured. Further, tibial and femoral sockets were made using the drill to which the graft was fixed in the correct position. The graft tension was checked for symmetry with a minimum of 5 cycles of knee extension and flexion [11, 13, 14].

Group II: ACL reconstruction by preserving HG tibial insertion [11, 14, 15]

Semitendinosus (ST) and gracilis tendon were harvested while maintaining their tibial insertion. The harvested tendons were sutured together. A reamer was used for creating the tibial tunnel from the anteromedial portion of the tibial metaphysis approximately 1 cm medial and proximal in respect to the hamstring tibial insertion. A retrograde drill was used for creating the femoral socket. The FlipCutter was inserted approximately 1 cm anterior to the posterior border of the iliotibial tract and 1.5 cm proximal to the lateral femoral epicondyle, in order to drill a retrorocket of at least 25 mm, according to the width of the lateral femoral condyle [11, 14, 15].
The graft of was fixed on the lateral femoral condyle with a cortical suspensory device. Keeping the knee in 90° flexion, femoral fixation was achieved by pulling the femoral pull suture. Then flexing the knee to 30°, the graft remnant was fixed with a titanium staple placed at the level of the tibial metaphysis distally with respect to the HG insertion [11, 14, 15].

Post-operative rehabilitation

Post-surgery, all patients underwent a rehabilitation program during which a rigid "extension brace" was placed to avoid knee flexion contracture. The patients were allowed to begin continuous passive motion (0- 40 degrees) immediately on the following day of surgery. They were allowed limb loading in a progressive manner during the following 2 weeks with an aim to reach an extended motion to 100 degrees. By the third week, full weight bearing was allowed without the brace. Then further with the help of physiotherapy exercises, strength in the muscles was gained to achieve normal physical activity and sports activity.

Outcomes

The clinical evaluation in both groups was performed pre-operatively and post-operatively at 12 months using the stability test: Lachman and pivot shift test. The functional assessment and return to sports activities were evaluated by means of the Tegner Activity Scale and Lysholm Score in the follow-up period of 12 months. The radiological evaluation was performed by analyzing the MRI (1.5-tesla whole body scanner) that had been performed at one-year post-reconstruction in both groups. The Ligamentization and integration of the graft were assessed as per the protocol of Figueroa *et al*. [10]. The graft signal intensity by the MRI was labelled as 1= hyperintense, 2=isointense, and 3=hypo intense. The presence of synovial fluid at the graft tunnel interface was reported as 1=positive and 2=negative. The overall Figueroa score was calculated as per both these items and as per the final scoring: 2 points represented an insufficiently mature graft, while a score between 3 and 5 points represented a good Ligamentization process and graft integration.

Statistical analysis

The data entry was done in Microsoft Excel and analysed using Statistical Package for Social Sciences (SPSS) software ver 21.0. The categorical variables were represented as number (n) and percentage (%) while continuous variables were presented as mean ± SD and median values. The comparison of quantitative variables were done by Independent t-test (normally distributed data) and Mann-Whitney Test (data not normally distributed). The comparison of qualitative variables were done by Chi-Square test/Fisher's exact test. For statistical significance, p-value of less than 0.05 was considered as significant.

Results

In Group I, the mean age of the patients was 29.44±5.87 years with 84% males and 16% females. The side affected was right in 60% and left in 40% of patients, and the common modes of injury were Sports injury in 44%, RTA in 32%, and fall in 24%.

In Group II, the mean age of the patients was 31.53±6.6 years with 86.67% males and 13.33% females. The side affected was right in 56.67% and left in 43.33% of patients, and the common modes of injury were Sports injury in 53.33%, fall in 26.67%, and RTA in 20%. The baseline demographic characteristics were comparable between groups I and II ($p>0.05$) as shown in Table 1.

In Group I, pre-operatively, Lachman test showed grade 2 in 14(56%) patients and grade 3 in 11(44%) patients which improved to grade 0 in the majority (76%) post-operatively ($p<0.0001$). The pivot shift test was positive in 13(52%) cases pre-operatively which became negative in all patients post-operatively ($p<0.0001$).

In Group II, pre-operatively, the Lachman test showed grade 2 in 7(23.33%) patients and grade 3 in 23 (76.67%) patients which improved to grade 0 in the majority 27 (90%) post-operatively ($p<0.0001$). The pivot shift test was positive in 25 (83.33%) cases pre-operatively which became negative in all patients post-operatively (p=0.052) (Table 2).

In Group I, the mean Lysholm score improved from 63.6±7.47 (pre-operatively) to 92.04±6.7 (post-operatively), $p<0.0001$, and in Group II, it improved from 63.53±7.35 (pre-operatively) to 96±2.36 (post-operatively), $p<0.0001$. The mean improvement in the Lysholm score was significantly higher in Group II as compared to Group I (32.467 vs 28.440). (Table 3 and Figure 1)

In Group I, the mean Tegner activity score improved from 2±0.71 (pre-operatively) to 3.52±0.65 (post-operatively), $p<0.0001$, and in Group II, it improved from 2 ± 0.64 (pre-operatively) to 5.2 ± 1.03 (post-operatively), $p<0.0001$ (Table 3 and Figure 2).

Compared to Group I, Group II had significantly more cases with hypo-intense graft intensity 3 (66.67% vs 24%, p=0.001) and less synovial fluid at the graft tunnel interface (3.33% vs. 52%, $p<0.0001$).

Overall taking into account both the MRI parameters, graft Ligamentization was better in Group II as compared to Group I ($p<0.0001$) with 70% of cases having Figueroa score 5 as compared to 24% in Group I (Table 4).

Discussion

The quick Ligamentization and regain of functional ability are crucial in ACL reconstruction. The present study showed that the preservation of tibial insertion of the HG proved beneficial in significantly showing better Ligamentization, graft integration, and functional recovery at the end of 12 months. This may be ascribed to two reasons (1) improved proprioception post-ACL reconstruction [16] and (2) the reduction in graft necrosis in the postoperative period due to better maintenance of the neurovascular network [17]. Besides sparing the HG insertion, 17 researchers have tried bone marrow-derived cells administration or platelet-rich fibrin injections to enhance the rehabilitation [18-20], but the evidence has not been definitive.

The findings of the present study corroborated with a few of the previous studies [11, 21-25] which showed faster graft integration with preservation of HG tibial insertion. Besides, few case reports and series indirectly support the present study findings.

Marcacci *et al*. [1] observed the absence of "Osteolysis" or "Tunnel Widening" after ACL reconstruction with inserted HG during an 11-year follow-up. In another study Zaffagnini *et al*. [25] observed a lower rate of tunnel enlargement with the use of HG tibial insertion preservation as compared to HG tibial detachment.

In the present study, a retrospective collection of the data was done whereby randomization and blinding could not be done. The absence of a complete tibial tunnel in the patients may be a source of bias in the comparison. The comparative MRI analysis showed a better intra-articular graft portion in Group II, substantiating for better ligamentization process and graft integration. The findings were similar in line with the study by Ruffilli *et al*. [11]

Barring improvement in Pivot shift test in Group II, overall, the clinical improvements were significant in both the study groups. The comparison showed significantly better stabilometric parameters with HG insertion sparing. The findings are in line with the MRI findings which explains the low morbidity of single bundle ACL reconstruction.

Limitations of the study

The study results must be interpreted in view of certain limitations. First, the sample size calculation was done on the presumption of a pilot study and the total number of patients included is low for inference of a definitive conclusion. Second, the follow-up period was short (12 months) and the MRI evaluation was done only at 12 months without any intermediate evaluation at 3 or 6 months. An intermediate evaluation of the reconstruction could have highlighted the process of Ligamentization progression thus allowing a better comprehension of the graft biology. Last, the study was retrospective in design, and thus the association of various demographic and clinical parameters with the recovery could not be assessed.

Conclusion

In conclusion, preservation of HG insertion provides a better functional recovery, graft Ligamentization, and graft integration. Further randomized trials are required with larger sample size, longer follow-ups, and serial intermediate MRI evaluations to validate the present findings and lay the treatment guidelines for ACL reconstruction.

Declaration

Ethical clearance

Approval for conducting the study was taken from the Institutional ethical committee.

Contributors

DS, BPG, RKD, And HSS: Concept and design; DS, BPG, AD: Data collection, review of literature; DS, BPG, RKG, HSS, GP: Drafting of the manuscript, DS, BPG, GP: Data analysis, statistics and data interpretation. DS, BPG, RKG, HSS, GP: Intellectual input, critical revision, and finalization of the manuscript. All authors provided final approval of the version to be published.

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Conflict of Interest:

The authors declare that they have no known competing financial interests or personal relationships that could have

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