Original Article

Anterior Cruciate Ligament Reconstruction with Tibial Attachment Preserving Hamstring Graft without Implant on Tibial Side

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Abstract

Background: Tibial attachment preserving hamstring graft could prevent potential problems of free graft in anterior cruciate ligament (ACL) reconstruction such as pull out before graft-tunnel healing or rupture before ligamentization. Different implants have been reportedly used for tibial side fixation with this technique. We investigated short-term outcome of ACL reconstruction (ACLR) with tibial attachment sparing hamstring graft without implant on the tibial side by outside in technique. **Materials and Methods:** Seventy nine consecutive cases of ACL tear having age of 25.7 ± 6.8 years were included after Institutional Board Approval. All subjects were male. The mean time interval from injury to surgery was of 7.5 ± 6.4 months. Hamstring tendons were harvested with open tendon stripper leaving the tibial insertion intact. The free ends of the tendons were whip stitched, quadrupled, and whip stitched again over the insertion site of hamstring with fiber wire (Arthrex). Single bundle ACLR was done by outside in technique and the femoral tunnel was created with cannulated reamer. The graft was pulled up to the external aperture of femoral tunnel and fixed with interference screw (Arthrex). The scoring was done by Lysholm, Tegner, and KT 1000 by independent observers. All cases were followed up for 2 years. **Results:** The mean length of quadrupled graft attached to tibia was 127.65 ± 7.5 mm, and the mean width was 7.52 ± 0.78 mm. The mean preoperative Lysholm score of 47.15 ± 9.6, improved to 96.8 ± 2.4 at 1 year. All cases except two returned to the previous level of activity after ACLR. There was no significant difference statistically between preinjury (5.89 ± 0.68) and postoperative (5.87 ± 0.67) Tegner score. The anterior tibial translation (ATT) (KT 1000) improved from 11.44 ± 1.93 mm to 3.59 ± 0.89 mm. The ATT of operated knee returned to nearly the similar value as of the opposite knee (3.47 ± 1.16 mm). The Pivot shift test was negative in all cases. None had a failure of graft till final followup. **Conclusion:** Attachment sparing hamstring graft without a tibial implant is a simple, cost-effective technique that provides a consistently satisfactory outcome.

Keywords: *Anterior cruciate ligament, attachment preserving hamstring graft, reconstruction*
MeSH terms: *Anterior cruciate ligament, reconstruction, tibia, autograft, knee*

Introduction

The technique of arthroscopic anterior cruciate ligament reconstruction (ACLR) has undergone many modifications in the recent times with improved understanding of anatomy, kinematics, and biology of the graft.[1-3]

Autologous free hamstring graft is a popular choice currently. The free graft could be potentially associated with problems because of it being avascular. Free hamstring graft undergoes necrosis for the first 4 weeks followed by revascularization and ligamentisation.[4] In this period of revascularization, the free graft is weakest, and there is risk of into substance rupture.[4,5] The tibial fixation site is supposed to be potentially weak link in ACLR[2] and there could be risk of graft pull out from tunnel before there is graft-tunnel healing.[4,5]

To overcome the potential problems of free graft in ACLR, the technique of tibial attachment preserving hamstring graft could be helpful. Tibial attachment preserving hamstring graft in animal model has shown promising result as the graft viability is preserved and the stage of avascular necrosis and revascularization is bypassed.[3]

There are only a few clinical studies on ACLR in which tibial attachment preserving hamstring graft is used.[6-10] The implants that have been used for tibial side fixation in attachment preserving hamstring graft with good clinical outcome are interference screw,[6,7] staple,[7-9] barbed staple,[10] and interference screw with staple.[11]

How to cite this article: Sinha S, Naik AK, Maheshwari M, Sandanshiv S, Meena D, Arya RK. Anterior cruciate ligament reconstruction with tibial attachment preserving hamstring graft without implant on tibial side. Indian J Orthop 2018;52:170-6.

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Access this article online
Website: www.ijoonline.com
DOI: 10.4103/ortho.IJOrtho_85_17
Quick Response Code:

The tibial insertion of hamstring can be used to suture free proximal end of the graft, as it is strong and vascularized. Recently, Sacramento *et al*. have reported satisfactory clinical outcome and stability with tibial attachment preserving double bundle ACLR without implant on tibial side.[12]

We investigated clinical outcome of hamstring attachment preserving anatomic single bundle ACLR by outside in technique with a femoral tunnel instead of a socket, in which no implant was used for fixation on tibial side. To the best of our knowledge, there is no literature on true implant less fixation on the tibial side with outside in technique of anterior cruciate ligament (ACL) reconstruction.

We hypothesized that can single bundle ACLR with tibial attachment preserving quadrupled hamstring graft without implant on the tibial side provide a satisfactory clinical outcome?

Materials and Methods

This study was prospective case series conducted on skeletally mature subjects with ACL tear after approval of the institutional board. The sample size was calculated by paired *t*-test. The total sample size 76 was calculated from an effect size of 0.50, with a power of 99%, and an α of 0.05 where the standard deviation of Lysholm score (LS) preoperatively and postoperatively was assumed to be 20.

Seventy nine consecutive cases operated between November 2012 and April 2014, were included in this study. The diagnosis was made clinically (Lachman, Anterior Drawer, Pivot shift, and Mcmurray test) and confirmed by MRI in all cases. Informed consent was obtained from all the cases.

All the cases with isolated ACL tear with or without meniscal injury were included in the study. The cases with bony avulsion of ACL, associated other ligament injuries, cartilage lesions, intraarticular fractures, ACL tears in arthritic knee, and pediatric ACL tear were excluded from the study.

Operative procedure

After sterile preparation, through a 3 cm oblique incision over an anteromedial aspect of the leg at the level of tibial tuberosity, Semitendinosus and Gracillis tendons were harvested with open tendon stripper leaving the tibial insertion intact. The tendons were cleared of muscle tissue, and the free ends of both were whip stitched using Vicryl suture. The whip stitched free ends of the tendons were then quadrupled over number 5 Ethibond suture and whip stitched again over insertion site of hamstrings using a Fiberwire (Arthrex) [Figure 1a]. The dimension (diameter and length) of the prepared graft was measured, and the graft was placed back in the area of harvest [Figure 1b] so that it remains in the physiologic environment. A stay suture was applied at the harvest site.

Arthroscopy was done with knee placed over the post in 90° of flexion. The femoral tunnel was prepared by outside in technique using 115° ACL guide (Arthrex) placed over the femoral footprint of ACL [Figure 2a].[1,6] The ACL

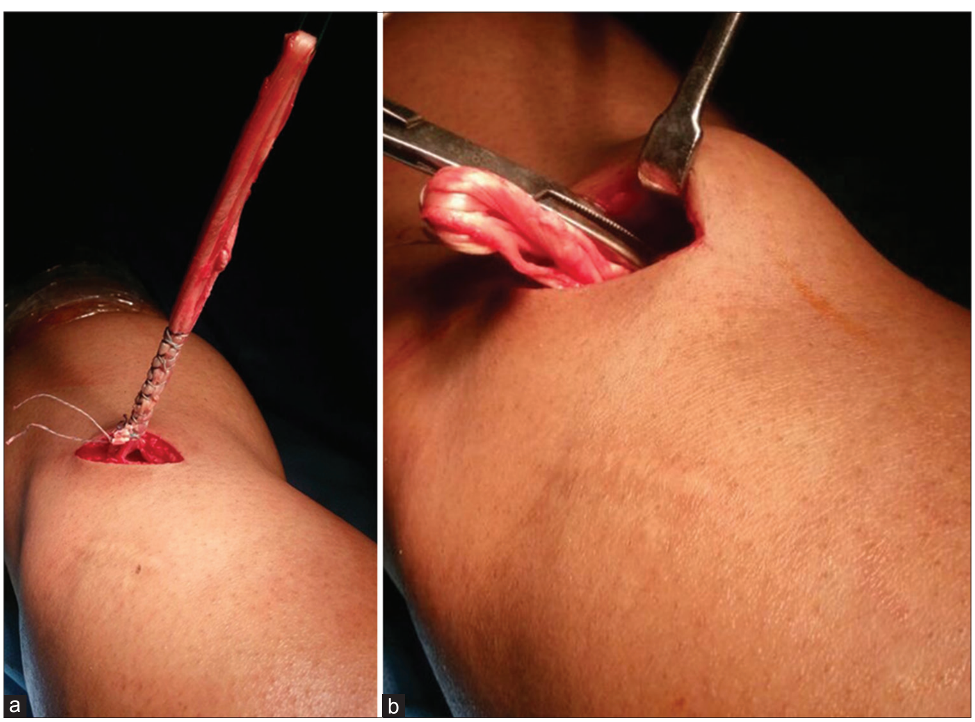

Figure 1: Intraoperative photograph showing (a) Quadrupled hamstring graft whip stitched at tibial insertion (b) Prepared graft placed back in harvest bed

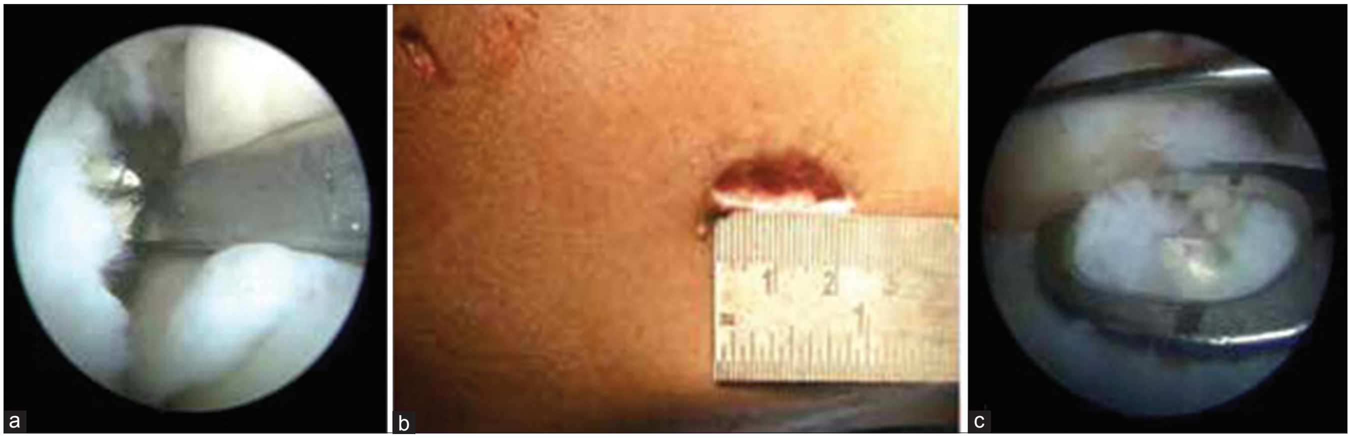

Figure 2: (a) Intraoperative fluoroscopy image showing that femoral guide in place with guide wire exiting at femoral footprint of anterior cruciate ligament. (b) Incision on femoral side for outside in technique (c) Intraoperative fluoroscopy image showing that guide wire through tibial footprint of anterior cruciate ligament

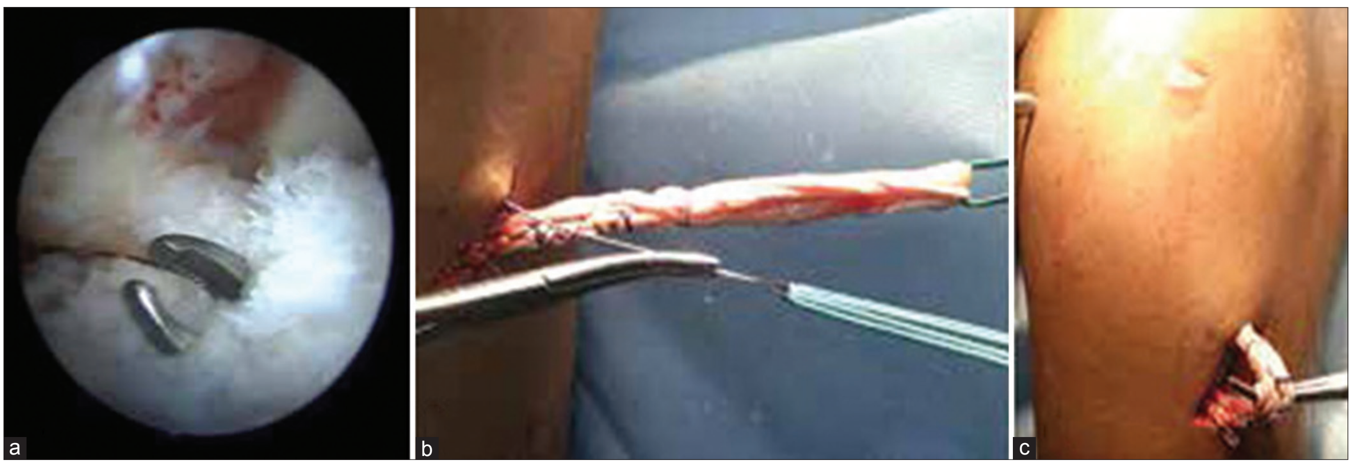

Figure 3: (a) Intraoperative fluoroscopy image showing that messenger wire from femoral tunnel and joint being passed through tibial tunnel (b) Loading of Ethibond (connected to graft) on messenger wire (c) Graft passage

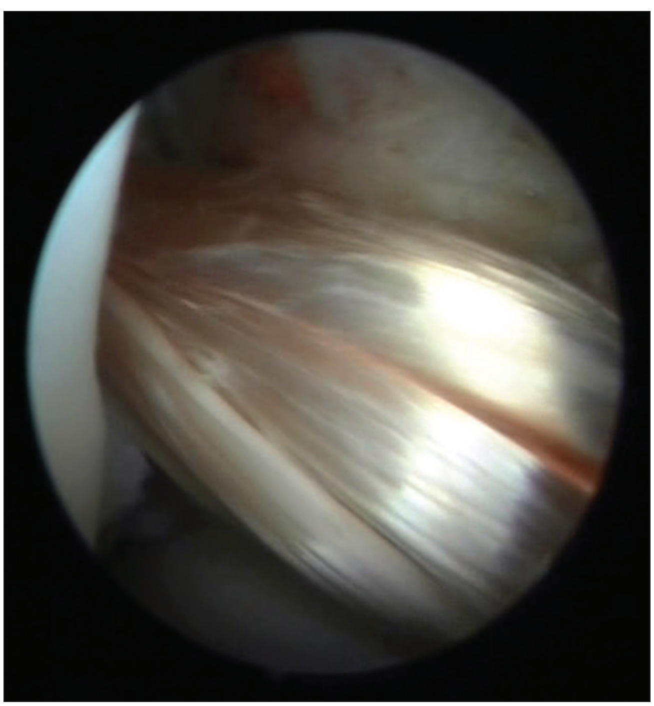

Figure 4: Fluoroscopic view showing final intraarticular graft

remnant over footprint was not debrided completely on either side. The guide wire was passed, and a 2–3 cm incision [Figure 2b] was made over the lateral side of thigh centered at guide wire. Sequential drilling outside in with cannulated reamers (instead of the flip cutter) over the guide wire created the tunnel of graft diameter. Stay suture was removed from graft harvest site. Tibial tunnel was created by placing the 50° guide placed at the tibial footprint of ACL [Figure 2c] with external starting point 2 cm medial to the tibial tuberosity. A messenger wire was passed through a femoral tunnel through joint, tibial tunnel to exterior [Figure 3a]. An Ethibond number 5 suture loop connected to hamstring graft was delivered to femoral aperture by messenger wire [Figure 3b]. By pulling the Ethibond suture loop, the graft was passed through the tibial tunnel, knee joint, femoral tunnel and was pulled up to the external aperture of femoral tunnel [Figures 3b and 3c]. The graft seating on the tibia at external aperture was checked. The knee was put in a full range of motion (ROM) and examined arthroscopically for impingement of graft [Figure 4]. The graft conditioning was done by cycling the knee through full ROM (20 cycles) while maintaining a constant pull on the graft.

After tensioning the graft, a Nitinol wire was passed through the femoral tunnel beside the graft, and an interference screw (Arthrex biocomposite of the same size as of tunnel) was inserted with the knee in about 20° of flexion [Figure 5]. The stability of knee was checked, and the wound was closed. Routine antibiotic prophylaxis was given.

Patients were encouraged to bear as much weight as possible walking from the next day. Active straight leg raises, isometric quadriceps exercise, active knee curls against the resistance of Theraband and active knee bending with end-range assistance was initiated. ROM knee brace was given for ambulation only till patients regained quadriceps control. Routine followup was done at 2, 6, and 12 weeks and every 6 months.

Figure 5: Outside in interference fixation of the graft at femoral tunnel

The scoring was done by Lysholm and Tegner method. KT 1000 (Medmetric Corporation, San Diego, California) was used for the objective measurement of anterior tibial translation (ATT). Manual Pivot shift test was also performed under anesthesia before surgery. Time of return of quadriceps control after surgery was also noted. The assessment and scoring were recorded before surgery and at 1-year post-surgery by two observers who were not involved in surgery. At 2 year followup assessment of ATT by KT 1000 and pivot shift test was done. The statistical analysis was done with SPSS Version 13.0 (SPSS Inc, USA).

Results

The mean age was 25.7 ± 6.8 years (range 18-48 years). All subjects were male. The time interval from injury to surgery was in the range of 1–30 months with a mean of 7.5 ± 6.4 months. The most common mode of injury

Table 1: Descriptive statistics of clinical outcomes (*n*=79)

	Range	Mean±SD
Age (years)	18-48	25.7±6.8
Mode of injury (%)		
Fall from bike	46 (58.2)	
Sports	30 (37.9)	
Fall	2 (2.53)	
Dance	1 (1.26)	
Side of injury (%)		
Right	41 (51.8)	
Left	38 (48.1)	
Associated meniscal injury	32 (40.5)	
Time from injury to surgery in months	1-30	7.5±6.4
Tourniquet time in minutes	34-67	50.29±7.91
Followup in months	24	
Graft length in mm	115-140	127.65±6.65
Graft width in mm	6-9	7.52±78

SD: Standard deviation

Table 2: Comparison of paired samples statistics of clinical outcome (*n*=79)

	Range	Mean±SD	Difference of mean	95% CI of difference of mean	*P*
Pair 1					
Preoperative LS	25-66	47.15±9.68	49.67	47.47-51.87	0.00
Postoperative LS	91-100	96.82±2.47			
Pair 2					
Preinjury TS	5-7	5.89±0.68	0.01	−0.04-0.07	0.66
Postoperative TS	5-7	5.87±0.67			
Pair 3					
Preoperative KT-1000	7-14	11.44±1.93	7.85	7.39-8.31	0.00
Postoperative KT-1000	2-6	3.59±0.89			
Pair 4					
Postoperative KT-1000	2-6	3.59±0.89	0.13	−0.08-0.33	0.22
KT-1000 of NK	2-6	3.47±1.16			

LS=Lysholm score, TS=Tegner Score, NK=Normal knee, SD=Standard deviation, CI=Confidence interval was fall from the bike in 46 (58.2%) followed by sports in 30 (37.9%), incidental fall in 2 (2.53%) and dance in 1 (1.26%) [Table 1].

Meniscal injuries were found in 32 cases (40.5%). Two cases had a bucket handle tear in white zone of medial meniscus that was excised. Two cases of medial meniscus tear in the red zone were repaired, and rest of the cases had undergone partial meniscectomy with the indexed procedure.

The length of quadrupled graft obtained was 115–140 mm with a mean of 127.65 ± 7.5 mm and the mean width was 7.52 ± 0.78 mm. The tourniquet time was 34–67 min with a mean of 50.29 ± 7.91 min [Table 1].

The preoperative LS was 25-66 with a mean of 47.15 ± 9.6, which improved at 1-year postoperative to 91–100 with a mean of 96.8 ± 2.4. This improvement was statistically significant. The pre-injury (ACL tear) Tegner score (TS) was 5–7 with a mean of 5.89 ± 0.68. The TS at 1-year was 5–7 with a mean of 5.87 ± 0.67. The pre-injury and postoperative difference in TS were not significant statistically [Table 2]. All the cases could return to the preinjury level of activity except for two cases. One had associated bucket handle tear of medial meniscus in the white zone that was excised. The second case had presented for surgery 18 months after injury.

The preoperative ATT measured by KT 1000 that was in the range of 7–14 mm with a mean of 11.44 ± 1.93. It improved to 2–6 mm with a mean of 3.59 ± 0.89. The ATT of operated knee was nearly the same as that of the normal opposite knee, which was in the range of 1–6 mm with a mean of 3.47 ± 1.16. At 2 years, mean ATT was 3.4 ± 0.9. There was no statistically significant difference of ATT between operated and normal knees [Table 2].

All the cases regained near full ROM by 6 weeks. The pivot shift test was negative in all cases at followup. The followup period was 24 months, and there was no loss to followup.

Superficial infection at graft harvest site was observed in one case that resolved with debridement and antibiotic therapy.

Discussion

The free graft revascularizes and incorporates with the bone tunnels around 6 to 12 weeks postoperatively.[3,13,14] There are concerns about potential failure either by graft pull out from tunnel before graft-tunnel healing has occurred or by rupture before ligamentization has taken place.[2]

The technique of preserving the tibial insertion of the hamstring donor tendons maintains the biological insertion strength (four zones with a seamless blending of the tendon to bone)[15] that is resistant to failure on cyclical loading. There was no case of graft pull out from tunnels in this study validating the secureness of tibial side fixation without any implant. The fixation on the tibial side is known to be a weak link in ACLR as the tibial tunnel is more in the line of the vector of pull on the graft than the femoral tunnel.[16,17] As the hamstring insertion is slightly away from the external aperture of the tibial tunnel, the vector of pull on the insertion site will not be straight. This technique effectively eliminates the weakness of tibial side fixation hence reduces the chances of graft pull out from the tibial tunnel in the early phase. Secure fixation allows the patients to be put on accelerated rehabilitation. All cases in this study could regain nearly full ROM by 6 weeks because of accelerated rehabilitation. There is also the early return of Quadriceps control (3.5 days +/-2.4) that is required for unaided ambulation and in regaining normal gait pattern.

The common cause of failure in 12 weeks to 24 weeks is intrasubstance rupture of the graft[3] as the ligamentization is incomplete. We had no case of mid-substance graft failure. If the graft necrosis is minimized the chances of its failure due to mid substance tear in the early period is also minimized. By tibial attachment, sparing technique of hamstring graft preparation, the intact tibial insertion would provide nutrition to the graft.[3] The intact pes anserine insertion receives nutrition through inferior medial genicular artery.[18] The hamstring tendons have longitudinally oriented blood vessels from osteotendinous junction till myotendinous junction.[18] It is expected that during the process of incorporation of the graft in tunnel and ligamentization, only part of the length of the graft that is detached proximally would undergo initial avascular necrosis. Although in animal study, Papachristou reported a complete bypass of phase of necrosis of graft by this technique.[3]

Although there are concerns of angular-rotation of preserved tibial hamstring graft at tibial attachment side during accelerated rehabilitation and Bungee-cord effect of graft, we observed no graft-related issues or laxity till final followup. However, it is an issue of further investigation.

On the contrary, Buda's observation of 27% reduction in tibial tunnel diameter using attachment-preserving hamstring graft[19] could be in direct evidence of intact attachment being helpful in graft tunnel healing.

In attachment sparing hamstring graft, tensioning of the graft is technically demanding as one end is fixed. Buda *et al*.[8] and Natali *et al*.[20] tensioned the graft by pulling the free end of hamstring tendons outside the tibial tunnel after deploying suspensory fixation on the femoral side. For the graft movement in the femoral socket over the loop of cortical suspensory fixation, there has to be as lightly wider socket, but the technique described in this study has the advantage of an exact press fit of graft in the tunnel. As the graft tensioning is done from the femoral side, the creation of a femoral tunnel instead of a socket is advantageous as no calculation of graft length and tibial tunnel-femoral socket length is required. There is no risk of graft bottoming out as in femoral socket.

The technique of creation of femoral tunnel instead of socket also provides flexibility of fixation on the femoral side. If the graft is short of the external aperture of the femoral tunnel, then suspensory fixation or tape locking screw (TLS) fixation can be used.[21] However, we found graft length to be adequate (127.65 ± 7.5 mm) to reach up to an external aperture in all cases, which is required for outside in interference fixation. If the accessory insertion of hamstring tendons are carefully released, there is length gain of approximately 2 cm.[11] Longer bone-tunnel interface provides more contact area for graft tunnel healing. The last but not the least benefit of this technique is cost minimization.

All cases in the study except two could achieve the pre-injury level of activity as depicted by TS. The underachievement of two cases could not be attributed to the technique of ACLR as one case had presented late for surgery (18 months) and the other had a bucket handle tear of medial meniscus in the white zone. The patient satisfaction index with the technique was high as noted by improvement in LS to excellent in all cases. Further, there was no objective evidence of instability at the final followup with ATT of operated knee nearly the same as uninjured another knee.

The only disadvantage this technique is increased surgical duration, as the graft preparation and arthroscopy is done sequentially not side-by-side. To reduce tourniquet time, we did not use a tourniquet for graft preparation. The complication of superficial infection encountered in the study cannot be attributed to the technique of graft preparation. The reliability of this technique is depicted by no incidence of subjective or objective instability at followup.

The study indirectly indicates non-inferiority of this technique in comparison to standard free graft technique but lacking direct evidence of intact vascularity of graft or bypassing the phase of necrosis of free hamstring graft. This aspect needs to be further investigated by histopathology at different time interval but will have ethical hurdles.

ACLR using tibial attachment preserving hamstring graft preparation without implant on the tibial side is a simple, reproducible, and cost-effective technique that provides a consistently satisfactory clinical outcome. The natural tibial side insertion provides secure fixation and adds biology to the anatomic reconstruction.

Declaration of patient consent

The authors certify that they have obtained all appropriate patient consent forms. In the form the patient(s) has/have given his/her/their consent for his/her/their images and other clinical information to be reported in the journal. The patients understand that their names and initials will not be published and due efforts will be made to conceal their identity, but anonymity cannot be guaranteed.

Financial support and sponsorship

Nil.

Conflicts of interest

There are no conflicts of interest.

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