Original Article

Trans-tibial guide wire placement for femoral tunnel in single bundle anterior cruciate ligament reconstruction

Skand Sinha, AK Naik, CS Arya, RK Arya, Vijay K Jain, Gaurav Upadhyay

Abstract

Background: Femoral tunnel location is of critical importance for successful outcome of ACL reconstruction. The aim was to study the femoral tunnel created by placing free hand guide wire through tibial tunnel, using the toggle of the guide wire in the tibial tunnel to improve femoral tunnel location.

Materials and Methods: 30 cases of a single bundle quadrupled hamstring graft anterior cruciate ligament reconstruction by trans-tibial free hand femoral tunnel creation is studied in this prospective study. The side to side play of the guide wire in the tibial tunnel was used to improve the tunnel location on femoral wall. The coronal angle of the femoral tunnel was measured on the anteroposterior radiograph. The femoral tunnel location on the lateral radiograph of the knee was recorded according to Amis method. Lysholm scoring was done preoperative and at each follow up. Assessment of laxity was done by Rolimeter (Aircast™) and pivot shift test.

Results: The mean coronal angle of the femoral tunnel in postoperative radiograph was 47°. In lateral radiograph, the femoral tunnel was found to be >60% posterior on Blumensaat line in 67% cases (n = 20) and in the 33% cases (n = 10) it was anterior. The mean Lysholm score improved from 74.6 preoperative to 93.17 postoperative with no objective evidence of laxity.

Conclusion: The free hand trans-tibial creation of the femoral tunnel leads to satisfactory coronal obliquity, but it is difficult to recreate anatomic femoral tunnel by this method as the tunnel is consistently anterior in the sagittal plane.

Key words: Femoral tunnel, trans-tibial, ACL reconstruction, arthroscopy, single bundle

MeSH terms: Knee, anterior cruciate ligament, arthroscopy, anterior cruciate ligament reconstruction

Introduction

Femoral tunnel is of critical importance in ACL reconstruction. Improper placement of the femoral tunnel is a common cause of failure after ACL reconstruction. In single bundle reconstruction, obliquely directed graft, that is femoral bone tunnel at 10'O clock position resists rotatory loads better than vertically placed graft, which is close to the roof of the notch that is 12'O clock position.[1] Stanford *et al.*[2] compared native ACL obliquity with ACL graft obliquity which was done by trans-tibial technique using computer navigation. They found a significant difference in coronal angulation between the reconstructed and native ACL as the graft was more vertical in reconstructed ACL as compared to the native ACL.[2]

Department of Orthopaedics, Dr. RML Hospital, PGIMER, New Delhi, India

Address for correspondence: Dr. Skand Sinha,
Department of Orthopaedics, Dr. RML Hospital, PGIMER,
New Delhi - 110 001, India.
E-mail: skandsinha@gmail.com

Access this article online	
Quick Response Code:	Website: www.ijoonline.com
	DOI: 10.4103/0019-5413.156224

There have been many modifications to improve coronal obliquity of the graft in single bundle trans-tibial ACL reconstruction. Heming *et al.* passed guide wire through femoral footprint into tibial footprint of ACL for trans-tibial reconstruction but found that for anatomic reconstruction the tibial starting point has to be very close to the joint line.[3] Piasecki *et al.* in their cadaveric study have reported that creation of tibial tunnel approximately 16 mm distal to medial joint line and 9 mm posteromedial to medial margin of tibial tuberosity results in near anatomic drilling through femoral footprint but the tibial tunnel created is short (average 23.1 mm).[4]

Howell *et al.*[5] reported a satisfactory femoral tunnel obliquity if tibial tunnel had coronal obliquity of 65°–70°. Chhabra *et al.*[6] reported ideal coronal inclination of the tibial tunnel and improved femoral tunnel location by placing the tibial guide at the tibial footprint and external starting point on tibia midway between tibial tuberosity and posteromedial border. Kopf *et al.*[7] made starting point on the tibia more medial to improve coronal tilt of the tunnels, but the limiting factor to the medial starting point was medial collateral ligament. In spite of many modifications in single bundle ACL reconstruction by trans-tibial technique, obtaining optimum coronal obliquity of the femoral tunnel is a challenge.

We hypothesized that the femoral tunnel created by passing free hand guide wire through posterolateral aspect of the tibial tunnel improves the coronal obliquity of femoral tunnel and outcome. So we tried to evaluate prospectively this technique in a case series.

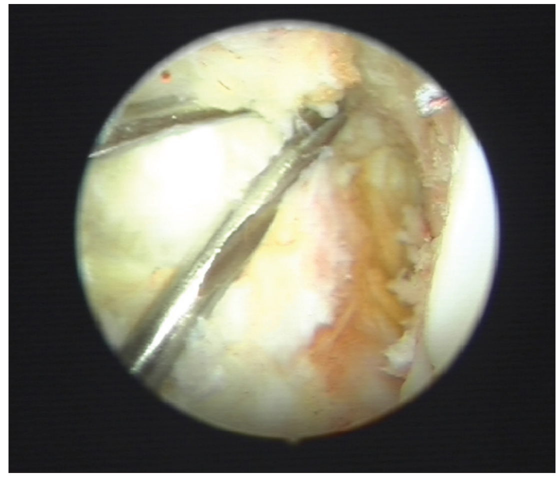

Figure 1: Arthroscopic picture showing trans-tibial guide wire

Materials and Methods

30 cases of a single bundle quadrupled hamstring graft anterior cruciate ligament reconstruction by trans-tibial free hand femoral tunnel creation is studied in this prospective study. Institutional approval was obtained for the study. Skeletally mature cases with isolated symptomatic ACL tear were included in the study. Cases with associated other ligament injuries or fractures were excluded. All cases were operated by same surgical team. The clinical and radiologic assessment was done by independent observer, not involved in surgery.

Operative procedure

Semitendinosus-gracilis tendons from the ipsilateral side were harvested and quadrupled graft was prepared. The diameter of quadruple graft was measured and it was mounted on tension board. Meanwhile, after diagnostic arthroscopy, the knee was positioned in 90° flexion to prepare the tibial tunnel using tibial guide set at 50° placed at the tibial footprint of ACL and lateral to medial tibial spine. The tibial guide was inclined to about 60° to tibial joint line in the coronal plane. The exit position of the guide wire on tibia and its coronal inclination was checked. A pilot hole of one size smaller than the final graft size was drilled in the tibia over the guide wire. Through the pilot tibial tunnel, a guide wire was passed into the intercondylar notch as close to the femoral footprint of native ACL as possible. At the same time, coronal angle of the guide wire was increased as much as possible so that it points more inferiorly on the lateral femoral condyle [Figures 1 and 2]. After checking the guide wire position, the final tunnel preparation on tibial and femoral side was undertaken according to the graft thickness. The free hand positioning of the guide wire was done through tibial tunnel that was one size smaller than final intended size to prevent iatrogenic posterolateralre reaming of the tibial tunnel during final size reaming of both tunnels. The length of the femoral tunnel was measured with direct measuring device. The graft was passed from tibia tunnel to the external aperture of the femoral tunnel. On femoral side suspensory fixation using fiber wire (Arthrex, Naples, Florida USA) with suture disk (HIB Surgicals, Mumbai, India) and on tibial side bioresorbable screw (Arthrex, Naples, Florida USA) interference fixation was used. The femoral tunnel width at surgery was noted.

After surgery, weight bearing with crutches was encouraged from day two of surgery. Active straight leg raise in all planes with aim to achieve quadriceps control without lag and active hamstring curls in the prone position and prone towel pulls were started from day 2 after surgery. Range of motion knee brace was applied for 1-month only for ambulation.

Antero-posterior (AP) and lateral radiographs of the knee in full extension were obtained in the postoperative period. In AP radiograph film coronal inclination of the femoral tunnel was expressed as the angle between a tangential line through distal articular surface of femoral condyles and a line through middle of the femoral tunnel [Figure 3]. In lateral radiograph film sagittal location of the femoral tunnel on Blumensaat line (BL) was expressed according to the method described by Amis[8] as a percentage of the length of BL [Figure 3].

The outcome was measured in terms of Lysholm score (LS), objective measurement anterior laxity by Rolimeter (Aircast™) testing device and manual pivot shift test at 6 weeks, 3 months, 6 months and 9 months.

Results

There were 29 males and 1 female. The average age was 27.7 years (range 18–48 years) and mean followup was 2.3 years (range 2–2.8 years). Femoral tunnel width

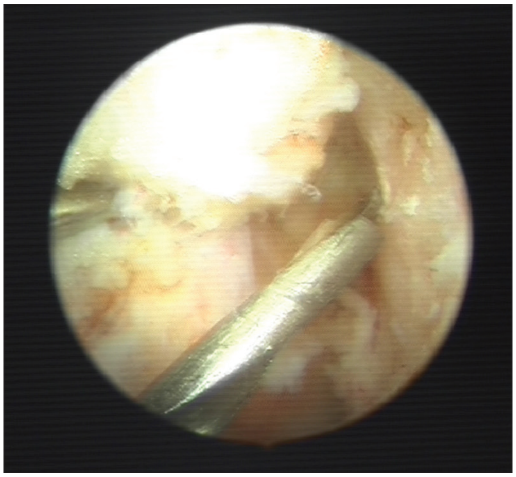

Figure 2: Arthroscopic picture showing guide wire with improved coronal angulation

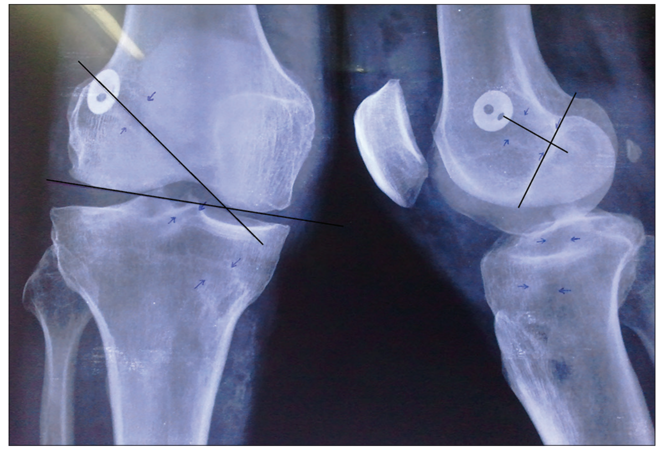

Figure 3: Postoperative X-ray of knee joint anteroposterior and lateral views showing femoral tunnel angle in coronal plane and sagittal location

obtained at the time of surgery was 6–8 mm, with a mean of 6.9 mm (±0.60). Femoral tunnel length obtained at surgery was between 45 and 55 mm, with a mean of 51 mm (±3.57). The coronal angle of the femoral tunnel was 40°–55° with a mean of 47° (±5.48). Out of 30 cases, 67% ($n = 20$) of cases had femoral tunnel located >60% posterior on BL and rest 37% ($n = 10$) were located anterior to it [Table 1].

Preoperative LS was in the range of 57–91, with a mean of 74.6, in comparison to postoperative LS that was in the range of 76–100, with a mean of 93.17. There was no recordable difference in LS according to sagittal location of the femoral tunnel [Table 1]. None of the case had positive pivot shift test in the postoperative period. Objective testing of anterior laxity by Rolimeter revealed >5 mm of laxity in all cases till last followup.

One case was unable to flex the knee beyond 120° at 6 months as he did not comply with the rehabilitation program. This patient was put on supervised rehabilitation (active knee curls with ankle in dorsiflexion against resistance of theraband and active knee bending with end range assistance with belt) for 1-month and regained full range of motion. There was no other complication noted in any other cases.

Discussion

Anatomical ACL graft placement is the most important factor for regaining normal postoperative knee function and kinematics after ACL reconstruction. In single bundle ACL reconstruction, the femoral tunnel should be correct in a location in AP direction as well as in correct coronal angulation which has to be achieved through trans-tibial tunnel. Restoration of knee function with a graft placed at the anatomical footprint of the ACL is better than graft placed at a position for best graft isometry that is anatomic reconstruction of ACL is better than the isometric reconstruction.[9] Amis *et al*. reported that a small area on the anterior side of femoral footprint of ACL from where anterior fibers of native ACL course, is close to isometry.[8] We found it difficult to judge the graft isometry per operatively in single bundle trans-tibial ACL reconstruction.

The femoral footprint of ACL is between the junction of the posterior cortex of femur and roof of notch (arthroscopic over the top position) at one end and from there it spreads in a distal and posterior direction on the lateral femoral condyle [Figure 4].[8] As the trans-tibial femoral tunnel creation is done with reference to over the top position, it is difficult to go inferior to this (toward articular margin of femur) position if a trans-tibial aiming device is used. By arthroscopic view in 90° flexed knee, the femoral tunnel cannot be aimed inferiorly in the anatomic footprint of ACL because of the constraint imposed by direction of the tibial tunnel. The reported closest position that can be reached is at the high and deep margin of the femoral footprint of native ACL.[10]

Study on free hand wire placement through tibial tunnel to improve femoral tunnel location was done by Bedi *et al*.[11] in a laboratory setting. They reported tibial tunnel intraarticular aperture widening by 38% in the AP dimension. They attributed it to iatrogenic rereaming of the tibial tunnel in which the trans-tibial wire is placed in the posterolateral aspect of the tunnel in a bid to improve the location of the femoral tunnel. In this study, to avoid this complication we under reamed the tibial tunnel by one size, then placed the trans-tibial guide wire over intended femoral point and then drilled the tibial and femoral tunnel with final size reamer.

Table 1: Case Details

Age	Sex	>60% post on BL	CA of FT	FT length in mm	FT width in mm at surgery	Pre op LS	LS at 6 m	FU (years)
27	M	NO	50	50	7	71	90	2.5
23	M	NO	54	55	7	71	95	2.5
35	M	YES	55	55	6	57	76	2.5
30	M	YES	55	55	8	71	90	2
33	M	NO	48	50	6	81	91	2.4
28	M	NO	50	45	7	82	95	2.4
30	M	YES	42	55	6	91	100	2
20	M	NO	40	45	6	91	100	2
20	M	NO	55	50	7	91	95	2.3
30	M	NO	50	50	7	86	100	2.6
48	M	NO	40	50	7	76	95	2.2
30	M	NO	42	55	7	75	100	2.6
27	M	YES	40	45	7	71	95	2.2
30	F	YES	44	50	7	91	100	2.2
18	M	YES	40	50	7	67	95	2.3
37	M	YES	42	55	7	81	92	2.8
20	M	YES	54	50	7	67	95	2.1
23	M	YES	42	50	6	66	95	2.1
25	M	YES	45	50	7	76	90	2.2
23	M	YES	42	55	8	83	95	2.4
22	M	YES	48	55	7	67	90	2
26	M	YES	52	50	6	57	90	2.4
30	M	YES	45	55	6	57	85	2.8
34	M	YES	42	45	8	67	90	2
30	M	YES	40	55	7	61	90	2
26	M	YES	52	50	7	67	90	2.2
25	M	NO	55	50	7	81	91	2.4
20	M	YES	48	45	7	67	95	2.1
28	M	YES	46	55	8	83	95	2.5
33	M	YES	52	50	7	86	95	2.3

BL=Blumensaat line, CA=Coronal angle, FT=Femoral tunnel, LS=Lysholm score

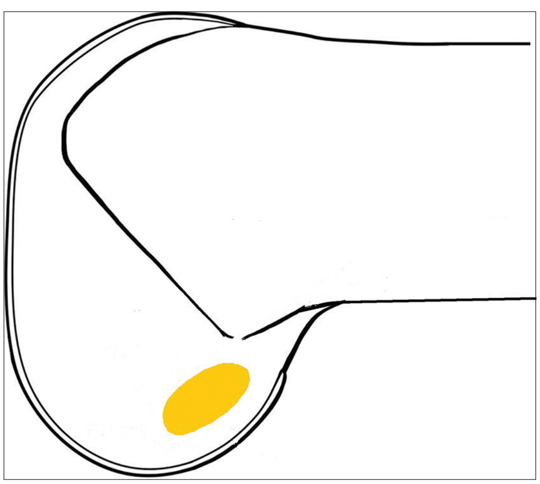

Figure 4: A line diagram of femoral footprint showing anterior cruciate ligament

The clinical outcome after ACL reconstruction correlates positively with posterior femoral tunnel placement on lateral radiographs and negatively with excessive anterior femoral tunnel placement.[12] Khalfayan *et al*. reported that when femoral tunnels were placed at least 60% posterior along BL, 69% of patients had good or excellent LS.[13] In this study, 67% cases had femoral tunnel located >60% posterior on BL and 37% were located anterior to it but we could not correlate the improvement in LS to the sagittal location of femoral tunnel. It has been shown that more posterior anatomic femoral tunnel creation through trans-tibial technique is possible if tibial tunnel is located posterior but posteriorly placed tibial tunnel is biomechanically inferior to the anatomic position of the tibial tunnel.[14,15]

For single bundle ACL reconstruction, coronal obliquity of graft is single most important factor for rotational stability of the knee. Femoral tunnel placed more obliquely toward 10'O clock position is more effective in resisting rotatory loads when compared with a tunnel placed close to the roof of the inter condylar notch. A vertically oriented femoral tunnel leads to laxity postoperatively and lesser patient satisfaction.[16] The reconstructed ACL can be closer to the native ACL by creation of a more horizontal tibial tunnel. Golish *et al*. reported that, by making the starting point of tibial tunnel close to anterior fibres of MCL the femoral tunnel obliquity can be improved to 10.30'O clock position.[17] But Silva *et al*. in their postoperative computed tomography evaluation of single bundle trans-tibial ACL reconstruction reported that even with tibial tunnel creation in 60–65° in relation to joint line, the reconstructed ACL was closer to anteromedial (AM) bundle not in the center of femoral footprint.[18]

In this study, the average coronal angle of the femoral tunnel was 47° that corresponds to approximately 10.30'O clock position that is required to position the graft between AM and PL bundle. The achievement of adequate coronal obliquity was an advantage of using free hand trans-tibial guide wire. When a femoral guide is placed through the tibial tunnel, there is no scope of play in any direction as the femoral guide fills the tibial tunnel, whereas when a free hand guide wire is passed through tibial tunnel, it has got a few millimeters of play which can be used to improve the femoral tunnel starting point. The trans-tibial femoral tunnel creation does not result in a critically short tunnel. The mean femoral tunnel length in this study was 51 mm, but long femoral tunnel is an indirect indicator of nonanatomic tunnel.[17]

Limitation of this study is a small study group by a single surgeon and lack of the control group.

To conclude, the femoral tunnel created by passing free hand guide wire through tibial tunnel to improve the location of femoral tunnel results in acceptable coronal angle but it is persistently anterior. The femoral tunnel created by this technique is not anatomic so should not be the preferred method of femoral tunnel creation.

References

1. Loh JC, Fukuda Y, Tsuda E, Steadman RJ, Fu FH, Woo SL. Knee stability and graft function following anterior cruciate ligament reconstruction: Comparison between 11 o'clock and 10 o'clock femoral tunnel placement 2002 Richard O'Connor Award paper. Arthroscopy 2003;19:297-304.
2. Stanford FC, Kendoff D, Warren RF, Pearle AD. Native anterior cruciate ligament obliquity versus anterior cruciate ligament graft obliquity: An observational study using navigated measurements. Am J Sports Med 2009;37:114-9.
3. Heming JF, Rand J, Steiner ME. Anatomical limitations of transtibial drilling in anterior cruciate ligament reconstruction. Am J Sports Med 2007;35:1708-15.
4. Piasecki DP, Bach BR Jr, Espinoza Orias AA, Verma NN. Anterior cruciate ligament reconstruction: Can anatomic femoral placement be achieved with a transtibial technique? Am J Sports Med 2011;39:1306-15.
5. Howell SM, Gittins ME, Gottlieb JE, Traina SM, Zoellner TM. The relationship between the angle of the tibial tunnel in the coronal plane and loss of flexion and anterior laxity after anterior cruciate ligament reconstruction. Am J Sports Med 2001;29:567-74.
6. Chhabra A, Diduch DR, Blessey PB, Miller MD. Recreating an acceptable angle of the tibial tunnel in the coronal plane in anterior cruciate ligament reconstruction using external landmarks. Arthroscopy 2004;20:328-30.
7. Kopf S, Martin DE, Tashman S, Fu FH. Effect of tibial drill angles on bone tunnel aperture during anterior cruciate ligament reconstruction. J Bone Joint Surg Am 2010;92:871-81.
8. Amis AA, Beynnon B, Blankevoort L, Chambat P, Christel P, Durselen L, *et al.* Proceedings of the ESSKA scientific workshop on reconstruction of the anterior and posterior cruciate ligaments. Knee Surg Sports Traumatol Arthrosc 1994;2:124-32.
9. Musahl V, Plakseychuk A, VanScyoc A, Sasaki T, Debski RE, McMahon PJ, *et al.* Varying femoral tunnels between the anatomical footprint and isometric positions: Effect on kinematics of the anterior cruciate ligament-reconstructed knee. Am J Sports Med 2005;33:712-8.
10. Arnold MP, Kooloos J, van Kampen A. Single-incision technique misses the anatomical femoral anterior cruciate ligament insertion: A cadaver study. Knee Surg Sports Traumatol Arthrosc 2001;9:194-9.
11. Bedi A, Musahl V, Steuber V, Kendoff D, Choi D, Allen AA, *et al.* Transtibial versus anteromedial portal reaming in anterior cruciate ligament reconstruction: An anatomic and biomechanical evaluation of surgical technique. Arthroscopy 2011;27:380-90.
12. Behrend H, Stutz G, Kessler MA, Rukavina A, Giesinger K, Kuster MS. Tunnel placement in anterior cruciate ligament (ACL) reconstruction: Quality control in a teaching hospital. Knee Surg Sports Traumatol Arthrosc 2006;14:1159-65.
13. Khalfayan EE, Sharkey PF, Alexander AH, Bruckner JD, Bynum EB. The relationship between tunnel placement and clinical results after anterior cruciate ligament reconstruction. Am J Sports Med 1996;24:335-41.
14. Brophy RH, Voos JE, Shannon FJ, Granchi CC, Wickiewicz TL, Warren RF, *et al.* Changes in the length of virtual anterior cruciate ligament fibers during stability testing: A comparison of conventional single-bundle reconstruction and native anterior cruciate ligament. Am J Sports Med 2008;36:2196-203.
15. Pearle AD, Shannon FJ, Granchi C, Wickiewicz TL, Warren RF. Comparison of 3-dimensional obliquity and anisometric characteristics of anterior cruciate ligament graft positions using surgical navigation. Am J Sports Med 2008;36:1534-41.
16. Lee MC, Seong SC, Lee S, Chang CB, Park YK, Jo H, *et al.* Vertical femoral tunnel placement results in rotational knee laxity after anterior cruciate ligament reconstruction. Arthroscopy 2007;23:771-8.
17. Golish SR, Baumfeld JA, Schoderbek RJ, Miller MD. The effect of femoral tunnel starting position on tunnel length in anterior cruciate ligament reconstruction: A cadaveric study. Arthroscopy 2007;23:1187-92.
18. Silva A, Sampaio R, Pinto E. Placement of femoral tunnel between the AM and PL bundles using a transtibial technique in single-bundle ACL reconstruction. Knee Surg Sports Traumatol Arthrosc 2010;18:1245-51.

How to cite this article: Sinha S, Naik AK, Arya CS, Arya RK, Jain VK, Upadhyay G. Trans-tibial guide wire placement for femoral tunnel in single bundle anterior cruciate ligament reconstruction. Indian J Orthop 2015;49:352-6.

Source of Support: Nil, **Conflict of Interest:** None.