ISSN: 0975-5160

Available online on www.ijtpr.com

International Journal of Toxicological and Pharmacological Research 2021; 11(4); 60-67

Original Research Article

Radiological Evaluation of Femoral and Tibial Tunnel Placement in Arthroscopic ACL Reconstruction Using Hamstring Graft: A Prospective Study

Bibek Kumar Rai[1], Ajoy Kumar Manav[2]

[1]Senior Resident, Department of Orthopaedics, Patna Medical College and Hospital, Patna, Bihar, India

[2]Associate Professor, Department of Orthopaedics, Patna Medical College and Hospital, Patna, Bihar, India

Received: 11-06-2021 / Revised: 06-07-2021 / Accepted: 20-07-2021
Corresponding author: Dr. Bibek Kumar Rai
Conflict of interest: Nil

Abstract

Aim: To evaluate the Radiological assessment of femoral and tibial tunnel placement in arthroscopic ACL reconstruction using hamstring tendon graft. **Methods:** This prospective study was carried out in the Department of Orthopaedics, Patna Medical College and Hospital, Patna, Bihar, India from January 2020 to November 2020, after taking the approval of the protocol review committee and institutional ethics committee. The study included patients using hamstring graft from either sex of ACL tear undergoing reconstruction of ACL. 50 patients were included in this study. Patients Diagnosed to have ACL tear clinically and radiologically with/without associated Menisci injuries, age group 14-60 years, and both male and female were included in this study. Patients with ACL injury in individuals associated with osteoarthritis, ACL avulsion fractures, observed chondral lesions that could modify the post op rehabilitation protocol, Collateral or/and PCL injuries and associated tibia plateau fractures and previously operated knee were excluded from this study. **Results:** This research included 50 patients undergoing reconstruction of ACL with hamstring tendon graft Aperture fastening using titanium screws. Male preponderance was noted in our study, with 90% of males and 10% of females in the total population of the sample. Most patients had a third decade of life, with the youngest patient being 18 years of age and the oldest being 60 years of age with a mean age of 33.5. The nature of the injury in our series was mainly Sports injury, which accounts for 36 patients (72%) and the rest were RTA, Work injury and slip and fall, respectively, which accounts for 14 (28%). The position of the tibial tunnel from the anterior edge of the tibia is found at an average of 45.98% ± 8.87% later. The femoral tunnel was located 37.4% ± 4.89% before the posterior femoral cortex along the axis of the Blumensaat's. Radiographic impingement was found in 33.5% of the patients. The roof angle averaged 40.8° with interquartile range of 4°. The position of the tibial tunnel was found at an average of 40.3% ± 4.3% from the medial edge of the tibial plateau. The coronal tibial tunnel angle averaged 59.7° ± 8.8°. The average femoral tunnel coronal angle was 40.8 ° ± 3.36 °. **Conclusion:** The radiological outcome for patients who underwent ACL reconstruction using hamstring tendon graft is that the placements of the femoral and tibial tunnels are well associated with anatomical landmarks except for graft impingement, which is seen radiologically in 33.5% of patients.

Keywords: Radiological Outcome, ACL, Hamstring Tendon Graft.

This is an Open Access article that uses a fund-ing model which does not charge readers or their institutions for access and distributed under the te rms of the Creative Commons Attribution License (http://creativecommons.org/licenses/by/4.0) and the Budapest Open Access Initiative (http://w ww.budapestopenaccessinitiative.org/read), which permit unrestricted use, distribution, and reproduction in any medium, provided original work is properly credited.

Introduction

In order to achieve a successful anterior cruciate ligament (ACL) reconstruction, optimum placement of the graft is crucial[1-3]. Non- anatomical placement of the bone tunnels is a very common cause that can lead to the failure of the ACL graft[4]. Mal positioning of the tunnels can give rise to abnormal tension in the graft, and thereby either stiffness of the knee, or recurrent instability[5-7]. These are all preventable by correctly judging guide wire placement intra- operatively by several techniques such as the use of femoral guides, fluoroscopy, and computer-assisted surgery[8-10].

Accurate placement of the tunnels is a challenging task. This not only minimizes the graft stretching but also averts the risk of re-rupture by avoiding notch impingement and improves rotational control[2,11].

The definition of the ideal tunnel position has observed major changes from time to time. In contrast to the earlier transtibial technique of ACL reconstruction, the newer transportal technique has its foundation in the concept of anatomical ACL reconstruction.

This novel concept emphasizes on reproducing the normal anatomy of the original ACL. This is achieved by placing the ACL graft at the center of the insertion sites of the original ligament[4]. In order to implement this principle one has to take reference of various anatomical landmarks. It has been found that these landmarks are not consistent and may be absent in some individuals[12,13]. Retaining the soft tissue of the torn ACL near its attachment site apparently helps to maintain post-reconstruction proprioception; hence clearing the remnants to accurately identify the footprints of the original ACL is not a favorable option[14]. On the contrary, locating the center of the footprint within those preserved remnants becomes a challenging task. Earlier reports showed significant variation in tunnel positioning[15]. One way of making guide wire placement less subjective is by using intraoperative fluoroscopy to cross-check the guide wire's position[16]. The standard radiographic position of tunnels described in the literature is mostly based on western population[2,6,11].

Material and methods

This prospective study was carried out in the Department of Orthopaedics, Patna Medical College and Hospital, Patna, Bihar, India from January 2020 to November 2020, after taking the approval of the protocol review committee and institutional ethics committee. The study included patients using hamstring graft from either sex of ACL tear undergoing reconstruction of ACL. Sample of 50 patients fulfilling the inclusion criteria were included in the present study after calculating on scientific basic with formula. Historical data collection and pub-med search was done. The sample size was calculated with statistical input from the following reference article: Radiologic assessment of femoral and tibial tunnel placement based on anatomic landmarks in arthroscopic single bundle anterior cruciate ligament reconstruction. Ethical clearance was taken from the institutional ethics review board (IERB) prior to conducting the study.

Patients Diagnosed to have ACL tear clinically and radiologically with/without associated Menisci injuries, age group 14-60 years, and both male and female were included in this

study. Patients with ACL injury in individuals associated with osteoarthritis, ACL avulsion fractures, observed chondral lesions that could modify the post op rehabilitation protocol, Collateral or/and PCL injuries and Associated tibia plateau fractures and Previously operated knee were excluded from this study. The information is compiled from the hospital database for patients who have undergone ACLR. These patients ' post- operative radiographs were collected. The research included postoperative full-extension antero-posterior and lateral knee x-rays. Radiographs with poor quality (inappropriate penetration), extreme obliquity for laterals (more than 5 mm lack of femoral condyle overlap), or inappropriately angled were excluded from the study. Postoperative radiographs of 35 patients who met the inclusion and exclusion criteria are included for measurements. Aperture fixation using titanium screws is used for all the cases included. The position of femoral and tibial tunnels on the postoperative radiographs is assessed by the reader.

VINFORMAX version 2.4.2 (IPACS VINCARE) was the method used. We examined 40 IPACS patients with postoperative radiographs. The research included postoperative full extension antero-posterior and lateral knee radiographs. Excluded from the sample were radiographs with poor quality (improper penetration), extreme lateral obliquity (more than 5 mm lack of femoral condyle overlap), or improperly shaped. Postoperative radiographs of 40 patients which met the inclusion and exclusion criteria were included for measurements. Aperture fixation using titanium screws was used for all the cases included. The position of femoral and tibial tunnels on the postoperative radiographs was assessed by the reader.

Statistics: All the patient data was entered in Microsoft Excel programmed analyzed by SPSS version 21.0. All the qualitative data are depicted as frequencies and percentage & all the quantitative data are depicted as Mean +/- SD and median with inter-quartile range

Results

This research included 50 patients undergoing reconstruction of ACL with hamstring tendon graft Aperture fastening using titanium screws. Male preponderance was noted in our study, with 90% of males and 10% of females in the total population of the sample. Most patients had a third decade of life, with the youngest patient being 18 years of age and the oldest being 60 years of age with a mean age of 33.5. The nature of the injury in our series was mainly Sports injury, which accounts for 36 patients (72%) and the rest were RTA, Work injury and slip and fall, respectively, which accounts for 14 (28%). The position of the tibial tunnel from the anterior edge of the tibia is found at an average of 45.98% ± 8.87% later. The femoral tunnel was located 37.4% ± 4.89% before the posterior femoral cortex along the axis of the Blumensaat's. Radiographic impingement was found in 33.5% of the patients. The roof angle averaged 40.8° with interquartile range of 4°. The position of the tibial tunnel was found at an average of 40.3% ± 4.3% from the medial edge of the tibial plateau. The coronal tibial tunnel angle averaged 59.7° ± 8.8°. The average femoral tunnel coronal angle was 40.8 ° ± 3.36 °.

Table 1: Showing the demographic details of the patients included in present study.

Variables		Frequency	Percentage
Gender	Male	45	90
	Female	5	10
	<20	6	12
	21-30	23	46

Age in years	31-40	9	18
	41-50	8	16
	51-60	4	8
Mode of Injury	RTA	14	28
	Sports	36	72
Side of injury	Right	53	56
	Left	22	44

Table 2: Table showing the various test and frequency of distribution

Test	Result	Frequency	Percentage
Anterior drawer test	Positive	46	92
	Negative	4	8
Lachman's test	Positive	43	86
	Negative	7	14
Posterior Drawer's	Positive	0	0
	Negative	50	100
Mc Murrey's test	Positive	6	12
	Negative	44	88

Table 3: Showing various radiological views and distribution among the patients.

Radiological views		Frequency	Percentage
Tibial tunnel sagittal view	21-30	4	8
	31-40	14	28
	41-50	20	40
	51-100	12	24
Femoral Tunnel sagittal view	0-25	0	0
	26-50	50	100
	51-75	0	0
Graft Impingment	<1	34	68
	1-25	11	22
	26-50	3	6
	51-75	1	2
	76-100	1	2
Tibial tunnel Coronal view	35-40	31	62
	41-45	16	32
	46-50	3	6
Angle of Tibial Tunnel	≤60	33	66
	60-65	5	10
	66-70	9	18
	≥70	3	6
Obliquity of Femoral Tunnel	≤35	4	8
	36-40	26	52
	41-45	17	34
	46-100	3	6
	≤30	3	6

Femoral Roof angle	31-35	3	6
	36-40	24	48
	≥40	20	40

Table 4: Distribution of radiological parameters in the study

Parameter	Mean ± SD	Category	N (%)
Position of tibial tunnel on sagittal radiograph from anterior edge of tibia(%)	45.98 ± 8.87	21-30	4
		31-40	14
		41-50	20
		51-100	12
Position of the femoral tunnel on sagittal radiograph along the Blumensaat's line (%)	37.4 ± 4.89	0-25	0
		26-50	50
		51-75	0
		76-100	34
Impingement of the graft on sagittal radiograph (%)	33.5%	0	11
		1-25	3
		26-50	1
		51-75	1
		76-100	31
Angle of the tibial tunnel on coronal radiograph (°)	59.7 ± 8.8	≤60	16
		60-65	3
		66-70	33
		≥70	5
Position of the tibial tunnel on coronal radiograph (%)	40.3 ± 4.3	35-40	9
		41-45	3
		46-50	4
		>50	26
Obliquity of the femoral tunnel on coronal radiograph (°)	40.8 ± 3.36	≤35	17
		36-40	3
		41-45	3
		≥46	3
Femoral roof angle radiograph (°) on sagittal	MEDIAN 40 with IQR 4.5	≤30	24
		31-35	20
		36-40	4
		>40	14

Discussion

The aim of ACLR surgery is to provide the torn ligament with an isometric, anatomic, impingement-free graft. The Multicenter ACL Revision Study[17]. showed some degree of technical error as the major cause of failure after ACLR either in isolation or in combination with trauma and/or biological problems 80 percent believed they had femoral tunnel malposition in the patients who felt they had technical problems contributing to their failure. For the effective placement of tibial and femoral tunnels for ACLR, various studies have identified arthroscopic and anatomic landmarks. We placed the femoral tunnel

slightly behind the native footprint center so that the tunnel has 1-3 mm of intact posterior wall and about 2 mm higher than the articular cartilage.

The femoral tunnel was positioned below the lateral inter- condylar ridge and slightly lateral to the bifurcate ridge in the absence of native footprint. The tibial tunnel was placed 3-4 mm ahead of the posterior cruciate ligament (PCL) and slightly medial to the lateral meniscus inner edge. Studies have investigated the relationship between arthroscopic anatomic landmarks and postoperative radiological and functional outcomes[18,19].

Nema SK, Balaji G, Akkilagunta S, Menon J[20] study showed placement of femoral tunnel at an average of 30 ± 10.7, We placed femoral tunnels at an average of 37.4% ± 4.89% anterior from the posterior femoral cortex along the Blumensaat's line. Studies have recommended placing the femoral tunnel at least 60% to 86% posterior along the Blumensaat's line[21].

A strong correlation has been shown between functional results and subsequent placement of femoral tunnels on lateral radiographs[18]. The angle of placement of tibial tunnels in the coronal plane is important in order to prevent postoperative impingement of the cruciate ligament and loss of flexion. In our analysis, the angle of the tibial tunnel in the coronal plane in 92% of patients was < 70 °.

Howell *et al*. reported a coronal plane angle >75° which was associated with loss of flexion and increased laxity. Pinczewski *et al*. placed location of the tibial tunnel in the coronal plane in their study at a mean of 46% (standard deviation 3) lateral to the medial border of the medial tibial plateau[18]. The location of tibial tunnel in our study was at a mean of 40.3% ± 4.3% lateral to the medial border of the medial tibial plateau.

Anterior impingement of the graft was examined and found to be associated with increased effusions, lack of extension, and increased rates of failure[22,23]. Studies subsequently suggested tibial tunnel positioning of about 50 percent (36 percent – 45 percent) along the length of the anterior tibial plateau in the impingement-free zone of 21–28 mm to prevent impingement[18,22,23]. Radiographic findings from the MARS cohort in revision ACLRs found variation in the location of tibial tunnels[17]. We did not quantitate the distance of tibial tunnel center in millimeters in this study, but the tibial tunnel was placed at an average distance of 45.98% ± 8.87% posterior from the anterior edge of tibia along the tibial plateau. we found placement of the tibial tunnel using anatomic landmarks, radiographic impingement ranging from 1% to 100% was found in 33.5% of the patients. Sudhahar *et al*. have demonstrated that the surgeon's ability to predict the femoral tunnel location is reasonable, but less so for tibial tunnel position[24].

A 45 ° postero-anterior weight bearing view (Rosenberg view) of the knee should be used to calculate the graft inclination. We calculated graft tendency indirectly due to patient factors in the study by calculating obliquity of the femoral tunnel on coronal radiograph. In our sample, the average angle of the femoral tunnel on coronal radiographs was 39 °. In this analysis, the femoral tunnel placement was guided by the tibial tunnel through an accessory antero-medial portal rather than the trans-tibial technique. Coronal obliquity of graft is one of the most crucial factors for rotational stability of the knee. A femoral tunnel placed obliquely is much more efficient in resisting rotatory loads if compared with vertical tunnel close to the roof of the inter-condylar notch. The reconstructed ACL can be closer to the native ACL if we position more horizontal femoral tunnel.

Conclusion

In this research, the radiological outcome for patients who underwent ACL reconstruction using hamstring tendon graft is that the placements of the femoral and tibial tunnels are

well associated with anatomical landmarks except for graft impingement, which is seen radiologically in 32.5% of patients.

Reference

1. 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 1. Arthrosc J Arthrosc Relat Surg. 2004;20(3): 328e330.
2. 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(3):335e341.
3. Amendola A, Menon M, Clatworthy M, Fowler PJ. The effect of fixation technique on graft position in anterior cruciate ligament reconstruction. Iowa Orthop J. 2003; 23:29.
4. Trojani C, Sbihi A, Djian P, et al. Causes for failure of ACL reconstruction and influence of meniscectomies after revision. Knee Surg Sports Traumatol Arthrosc. 2011;19(2):196e201.
5. Simmons R, Howell SM, Hull ML. Effect of the angle of the femoral and tibial tunnels in the coronal plane and incremental excision of the posterior cruciate ligament on tension of an anterior cruciate ligament graft: an in vitro study. JBJS. 2003;85(6):1018e1029.
6. 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(5):567e574.
7. Fujimoto E, Sumen Y, Deie M, Yasumoto M, Kobayashi K, Ochi M. Anterior cruciate ligament graft impingement against the posterior cruciate ligament: diagnosis using MRI plus three-dimensional reconstruction software. Magn Reason Imaging. 2004;22(8):1125e1129.
8. Kawakami Y, Hiranaka T, Matsumoto T, et al. The accuracy of bone tunnel position using fluoroscopic-based navigation system in anterior cruciate ligament reconstruction. Knee Surg Sports Traumatol Arthrosc. 2012;20(8): 1503e1510.
9. Musahl V, Burkart A, Debski RE, Van Scyoc A, Fu FH, Woo SLY. Accuracy of anterior cruciate ligament tunnel placement with an active robotic system: a cadaveric study. Arthrosc J Arthrosc Relat Surg. 2002;18(9):968e973.
10. Meuffels DE, Reijman M, Verhaar JAN. Computer-assisted surgery is not more accurate or precise than conventional arthroscopic ACL reconstruction: a prospective randomized clinical trial. JBJS. 2012;94(17):1538e1545.
11. Pinczewski LA, Salmon LJ, Jackson WFM, von Bormann RBP, Haslam PG, Tashiro S. Radiological landmarks for placement of the tunnels in single-bundle reconstruction of the anterior cruciate ligament. J Bone Joint Surg Br. 2008;90(2):172e179.
12. Kopf S, Pombo MW, Szczodry M, Irrgang JJ, Fu FH. Size variability of the human anterior cruciate ligament insertion sites. Am J Sports Med. 2011;39(1): 108e113.
13. Zauleck MK, Gabriel S, Fischmeister MF, Hirtler L. Origin of the anterior cruciate ligament and the surrounding osseous landmarks of the femur. Clin Anat. 2014;27(7):1103e1110.
14. Lee B-I, Kwon S-W, Kim J-B, Choi H-S, Min K-D. Comparison of clinical results according to amount of preserved remnant in arthroscopic anterior cruciate ligament reconstruction using quadrupled hamstring graft. Arthrosc J Arthrosc Relat Surg. 2008;24(5):560e568.
15. Topliss C, Webb J. An audit of tunnel position in anterior cruciate ligament reconstruction. Knee. 2001;8(1):59e63.

16. Hughes AW, Dwyer AJ, Govindaswamy R, Lankester B. The use of intraoperative fluoroscopy for tibial tunnel placement in anterior cruciate ligament reconstruction. Bone Joint Res. 2012;1(10):234e237.
17. MARS Group, Wright RW, Huston LJ, Spindler KP, Dunn WR, Haas AK, et al. Descriptive epidemiology of the Multicenter ACL Revision Study (MARS) cohort. Am J Sports Med. 2010; 38:1979-86.
18. Pinczewski LA, Salmon LJ, Jackson WF, von Bormann RB, Haslam PG, Tashiro S. Radiological landmarks for placement of the tunnels in single-bundle reconstruction of the anterior cruciate ligament. J Bone Joint Surg Br 2008; 90:172-9.
19. Sullivan JP, Matava MJ, Flanigan DC, Gao Y, Britton CL, Amendola A. MOON Group et al. Reliability of tunnel measurements and the quadrant method using fluoroscopic radiographs after anterior cruciate ligament reconstruction. Am J Sports Med. 2012; 40:2236-41.
20. Nema SK, Balaji G, Akkilagunta S, Menon J, Poduval M, Patro D. Radiologic assessment of femoral and tibial tunnel placement based on anatomic landmarks in arthroscopic single bundle anterior cruciate ligament reconstruction. Indian J Orthop. 2017; 51:286-91.
21. Postoperative Evaluation after Anterior Cruciate Ligament Reconstruction: Measurements and Abnormalities on Radiographic and CT Imaging Minchul Kim, MD1, Yun Sun Choi, MD, PhD1, Hyoungseop Kim, MD1, Nam-Hong Choi, MD kjr. 2016.17.6.919
22. 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.
23. Howell SM, Hull ML. Checkpoints for judging tunnel and anterior cruciate ligament graft placement. J Knee Surg. 2009; 22:161-70.
24. Sudhahar TA, Glasgow MMS, Donell ST. Comparison of expected vs. actual tunnel position in anterior cruciate ligament reconstruction. The Knee. 2004; 11:15-18.