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ORIGINAL RESEARCH

Influence of femoral and tibial tunnel obliquity on functional outcome in arthroscopic acl reconstruction: A prospective study

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Abstract
Background: Accurate direction of tibial and femoral tunnel has significant effect on functional outcome after anterior cruciate ligament reconstruction (ACLR). A vertical tunnel position high in the intercondylar notch near the 12-o'clock position has been shown to provide stability in the anteroposterior plane but does not restore rotational stability. Post-operative CT scan provide a reliable and valid way for the assessment of anatomical tunnel position and obliquity after ACLR.
Materials and Methods: 31 patients with complete ACL tear with or without the meniscal injury are treated with single bundle arthroscopic reconstruction using hamstring graft tendon. With common post-operative rehabilitation protocol all patient are followed up clinically and radiological for next 12 months. Tibia and femoral tunnel obliquity were measured interpreted with the clinical parameters. Radiological parameters were summarized as mean standard deviation and proportions as applicable.
Results: Total no of patients with the age averaged 27.13± 5.89, pre op lysholm score averaged 64.26± 8.93. At 1 year follow up. Femur tunnel coronal angle average of $37.52^0 \pm 5.04^0$ the coronal tibia tunnel was angle averaged of $72.23^0 \pm 2.44^0$.32.2% and 35.5% of patients showed grade 1 anterior drawer and Lachman test positive respectively. And mean lysholm score averaged to be 86.58±5.32.
Conclusion: Statistical analysis of our data showed negative significant correlation between femoral tunnel obliquity with lysholm score.
Keywords: Anterior cruciate ligament, lysholm score, obliquity, functional outcome.

Introduction

Improper placement of bone tunnels is a major reason for anterior cruciate ligament (ACL) reconstruction failure. Several cadaveric and clinical studies have focused on the anatomical tunnel placement in ACL reconstruction to better restore normal knee kinematics and to improve rotatory stability and long-term outcome.[1-3]Harner et al introduced the antero-medial (AM) portal technique for femoral tunneling to obtain a low-oblique drilling, which should be more anatomic than the traditional transtibial (TT) technique.[4-7]

Over the years, there has been considerable debate regarding the placement of the graft, and several studies have been conducted to identify the best location for the placement of the tibial tunnel in order to ensure optimal knee functioning. Initially, researchers proposed the

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placement of the graft in the anatomical position on the tibial plateau. However, with the advent of the concept of isometricity in graft positioning, either an anteromedial or a posterior isometric placement of the graft was recommended[12].

Other studies found that an anterior placement resulted in the impingement of the graft in the intercondylar notch, causing limitations in movement.[13]Despite the large number of studies relating to the ideal placement of the graft, no clear consensus has been reached thus far. So it is likely that the functional outcome of ACLR is dependent on the morphology as well as the pos. Stephen M. Howell studied 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 and concluded his study by angle of the tibial tunnel in the coronal plane is related to loss of flexion and anterior laxity when the femoral tunnel is drilled through the tibial tunnel[14]. Hence; under the light of above mentioned data, the present study was undertaken for assessing the influence of femoral and tibial tunnel obliquity on functional outcome in arthroscopic ACL reconstruction.

Materials & methods

The present study was undertaken for assessing the influence of femoral and tibial tunnel obliquity on functional outcome in arthroscopic ACL reconstruction. We reported the results of 31 cases of ACL reconstruction using hamstrings grafts that were followed up for a minimum period of 1year. The study was approved by the ethics committee of the institution, and informed consent was obtained from all the patients. The patient exclusion criteria included:

1. Patients with active infection,
2. Patient with stiffness of knee,
3. Preexisting osteoarthritis, inflammatory arthropathy.
4. Skeletal immaturity.
5. Associated posterior cruciate ligament injury, and medial and lateral collateral ligament injury periarticular fractures or cartilage injuries

The surgery was performed by the senior authors. The central third of the patellar tendon, measuring 9 mm, was used. Notchplasty was not done routinely; it was performed only when the intercondylar notch was found to be narrow. The tibial tunnel was placed in line with the inner margin of the anterior horn of the lateral meniscus, just posterior to the center of the ACL footprint lying about 6 mm anterior to the posterior cruciate ligament and 2-3 mm anterior to the peak of the medial tibial spine. The femoral tunnel was drilled tranportall technique. Graft was then fixed with one interference screw for the tibia and endobutton for the femur, a partial medial and lateral meniscectomy was performed in 15 and 16 knees, respectively. All patients were rehabilitated with common accelerated written rehabilitation protocol with clear drawings of every single exercise was also provided to all the patients so as to achieve maximum compliance. Knee swelling was managed with rest, ice, nonsteroidal anti-inflammatory drugs and partial weight bearing. Muscle strengthening exercises were started on the first postoperative day with isometric quadriceps contractions and progressed to active closed -chain exercises by 4-6 weeks postoperatively. Patients were allowed full weight -bearing three weeks postoperatively and returned to running after three months.

The patients were evaluated monthly by a blinded examiner up to 1 year. The modified Lysholm knee score was used for subjective evaluation of the knee post surgery. The final score was categorized into one of the four groups (Excellent: 95-100, Good: 84-94, Fair: 65-83 and Poor: < 64). At the end of 1-year computer tomography has done and calculated the accurate direction of the /axis of the tunnel calculated as follows:

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1. The coronal angle (obliquity) of the femoral tunnel (β) was determined by drawing a lineparallel to the femoral tunnel (F) and another line tangent to distal femoral condyles at the level of knee joint (T) and measuring the angle between them.
2. The orientation of tibial tunnel is measured between the two lines ,first one tangential line to the tibial plateau and one parallel line to the tunnel axis .the first angle(,α,)between the two lines.

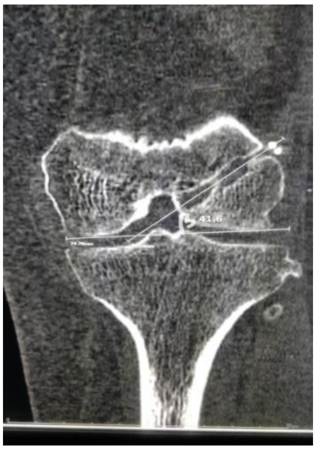

Figure no:1: femoral tunnel obliquity

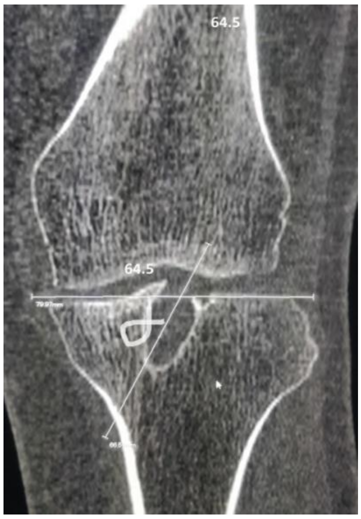

Figure no: 2 Tibial tunnel obliquity

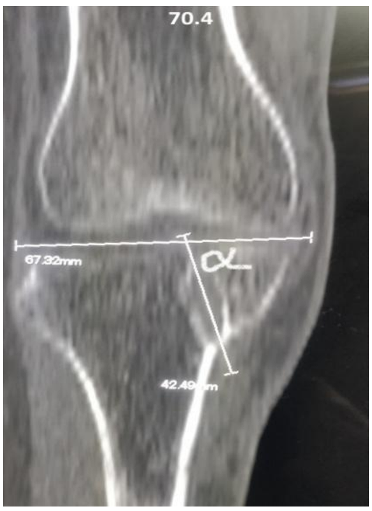

Figure no 3: tibial tunnel obliquity

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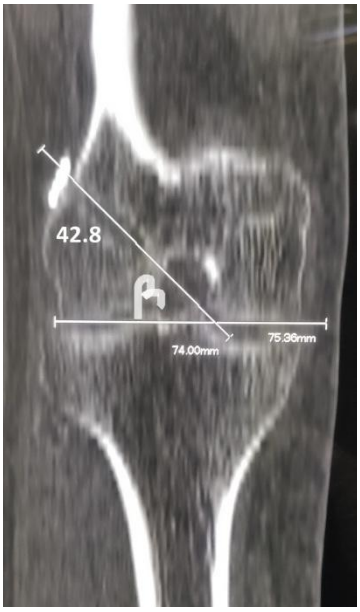

Figure no 4: femoral tunnel obliquity

Results

77.4 percent of the patients belonged to the age group of 20 to 30 years as shown in table 1. Total no of patients with the age averaged 27.13± 5.89, pre op lysholm score averaged 64.26± 8.93. At 1 year follow up. Femur tunnel coronal angle average of $37.52^0 \pm 5.04^0$ the coronal tibia tunnel was angle averaged of $72.23^0 \pm 2.44^0$.32.2% and 35.5% of patients showed grade 1 anterior drawer and Lachman test positive respectively as shown in table 2. And mean lysholm score averaged to be 86.58±5.32 as shown in table 3. At baseline, according to Lyscholm score, 71 percent of the patients were of fair grade while 29 percent of the patients were of poor grade as shown in table 4. At 2 years follow-up, according to Lyscholm score, 61.7 percent of the patients were of good grade while 12.9 percent of the patients were of excellent grade. Mean femoral tunnel obliquity was 37.52 while mean tibial tunnel obliquity was 72.23 as shown in table 5. Mean LYSHSCO among patients with ACL and ACL + MM was 26 and 28.33 respectively. Mean LYSHSCO after 2 years among patients with ACL and ACL + MM was 86.69 and 86.47 respectively as shown in table 6. According to Lysholm score at 2 years follow-up, good and excellent results were obtained in 67.7 percent and 12.9 percent of the patients respectively as shown in table 7. Non-significant results were obtained while comparing FE/TI TU OBL, FE/TI TU PO according to Lysholm Score at 2 years as shown in table 8.

Table 1: Age distribution of patients

Age in years	No. of patients	%
20-30	24	77.4
31-40	6	19.4
41-50	1	3.2
Total	31	100.0

Table 2: Assessment at baseline and 2 years of patients studied

Variables	Baseline	2 years	% difference	P value
Anterior drawer test				
• Negative	0(0%)	21(67.7%)	67.7%	<0.001**
• Positive	31(100%)	10(32.3%)	-67.7%	
Posterior drawer test				

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• Negative	0(0%)	31(100%)	100.0%	<0.001**
• Positive	31(100%)	0(0%)	-100.0%	
Lachman test				
• Negative	0(0%)	20(64.5%)	64.5%	<0.001**
• Positive	31(100%)	11(35.5%)	-64.5%	
Pivot shift test				
• Negative	0(0%)	31(100%)	100.0%	<0.001**
• Positive	21(67.7%)	0(0%)	-67.7%	

Chi-Square test/Fisher Exact test

Table 3: Assessment LYSHOLM SCORE at baseline and 2 years

LYSHSCO	Min-Max	Mean ± SD	difference	t value	P value
Baseline	46.00-77.00	64.26±8.93	-	-	-
2 years	76.00-95.00	86.58±5.32	-22.323	-12.143	<0.001**

Student t test (paired)

Table 4: Lysholm Score

Lysholm Score	Baseline	2 years	% difference
Poor	9(29%)	0(0%)	-29.0%
Fair	22(71%)	6(19.4%)	-51.6%
Good	0(0%)	21(67.7%)	67.7%
Excellent	0(0%)	4(12.9%)	12.9%
Total	31(100%)	31(100%)	-

P<0.001**, Significant, Paired proportion test, 80.6% improvement over 2 years

Table 5: femoral and tibial tunnel obliquity distribution of patients studied

Variable	No. of patients(n=31)	%	Mean ± SD
Femoral tunnel obliquity			
• <30	2	6.5	37.52±5.04
• 30-40	19	61.3	
• >40	10	32.3	
Tibial tunnel obliquity			
• <70	2	6.5	72.23±2.44
• 70-75	25	80.6	
• >75	4	12.9	

Table 6: Comparison of clinical variables according to diagnosis

Variables	Diagnosis		Total	P value
	ACL	ACL+MM		
Age in years	26.00±6.73	28.33±4.78	27.13±5.89	0.278
LYSHSCO	67.44±5.69	60.87±10.60	64.26±8.93	0.038*
LYSHSCO 2 years	86.69±6.27	86.47±4.29	86.58±5.32	0.910
FE TU OBL	37.38±5.71	37.67±4.40	37.52±5.04	0.875
TI TU OBL	71.74±2.74	72.75±2.04	72.23±2.44	0.257

Student t test

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Table 7: Lysholm Score

Lysholm Score	Baseline	2 years	% difference
Poor	9(29%)	0(0%)	-29.0%
Fair	22(71%)	6(19.4%)	-51.6%
Good	0(0%)	21(67.7%)	67.7%
Excellent	0(0%)	4(12.9%)	12.9%
Total	31(100%)	31(100%)	-

P<0.001**, Significant, Paired proportion test, 80.6% improvement over 2 years

Table 8: Comparison of FE/TI TU OBL, FE/TI TU PO c

Variables	Lysholm Score 2 years			Total	P value
	Fair	Good	Excellent		
FE TU OBL	37.32±5.86	37.37±5.02	38.63±5.13	37.52±5.04	0.902
TI TU OBL	71.40±3.78	72.75±2.09	70.73±0.62	72.23±2.44	0.211

ANOVA test

Figure No 5: Tibial tunnel obliquity

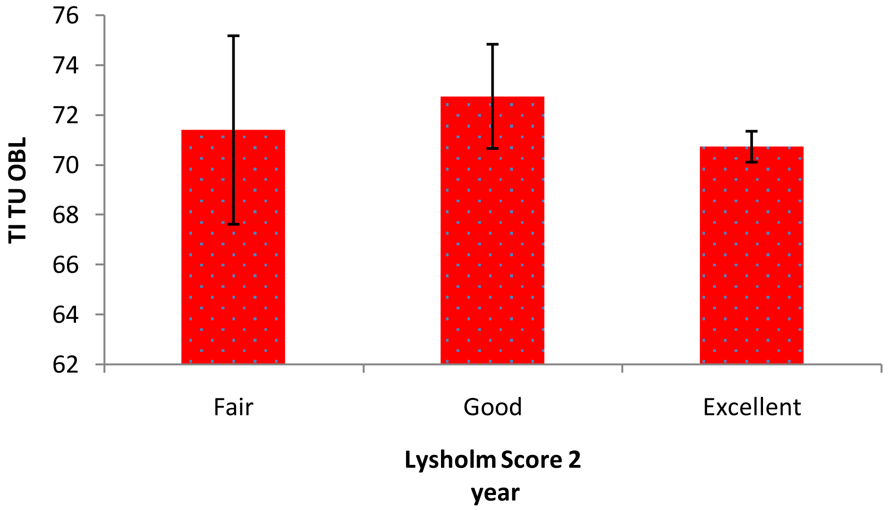

Figure no 6: Femur obliquity vslysholm at 2 years

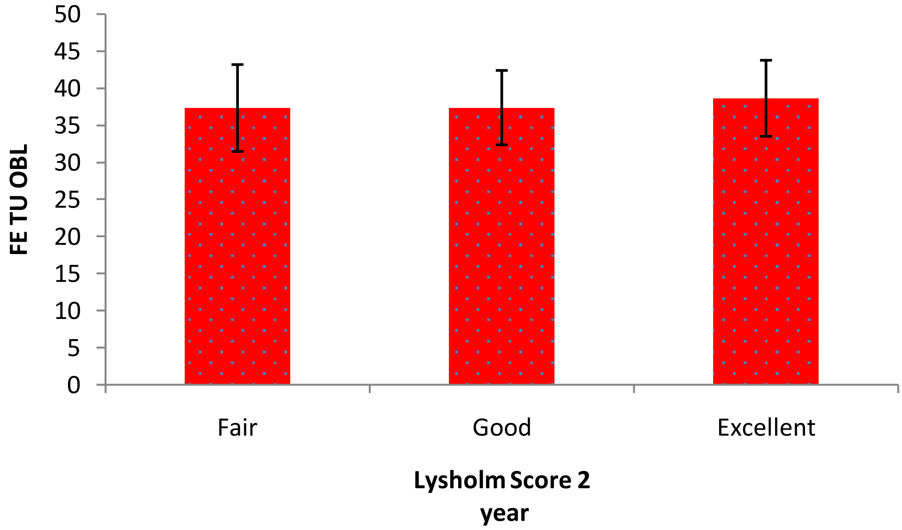

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Table 9: Pearson correlation of position, obliquity with lysholm score

Pair	r value	P value
LYSHSCOM 2 years **vs** FE TU OBL	-0.025	0.896
LYSHSCOM year **vs** TI TU OBL	0.021	0.910

Figure no 7: scatter plot tibial obliquity vslysholm 2 years

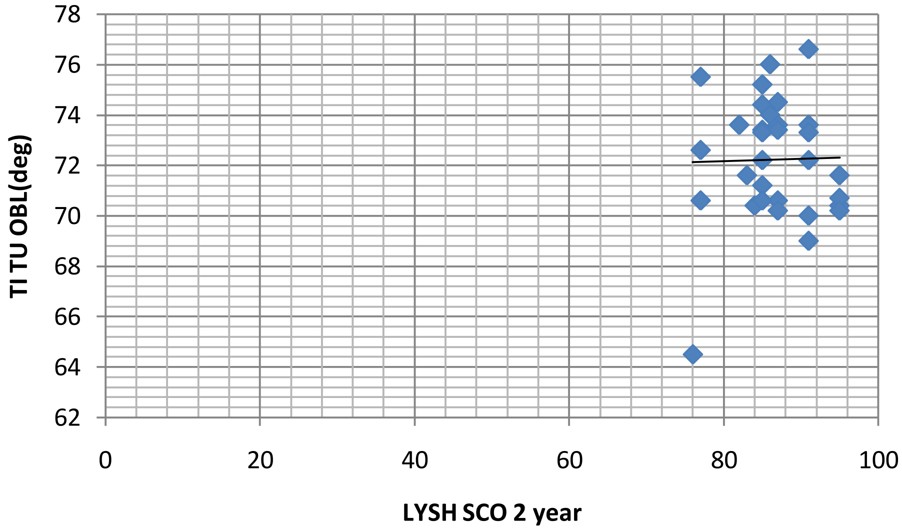
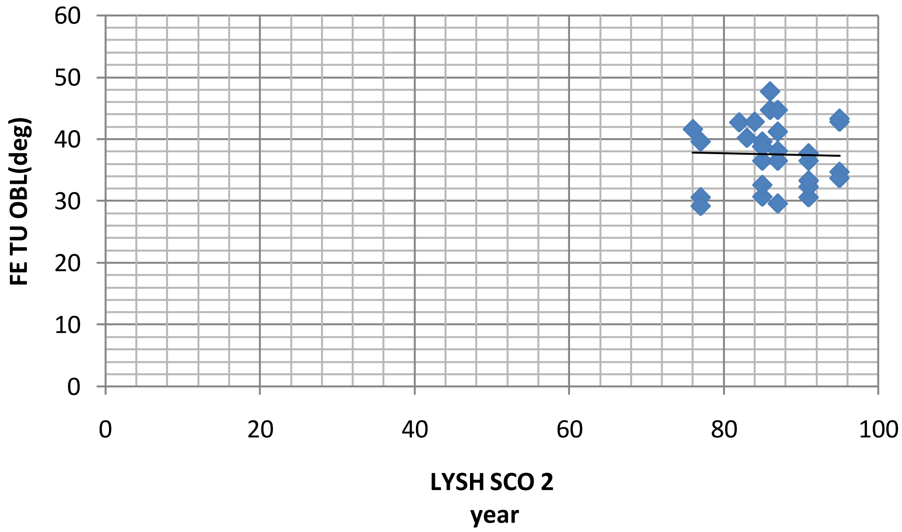


Figure no 8: scatter plot femur obliquity vslysholm 2 years



Discussion

Surgical management of anterior cruciate ligament (ACL) deficient knee has progressed from the earlier primary repair to extra capsular augmentation to ACL reconstructions (ACLR) utilizing tendon grafts. The autograft arthroscopic single-bundle surgery is considered the “gold standard” for ACLR. Femoral tunnel placement has been considered to be the most critical step in ACLR. It has been postulated that traditional single-bundle transtibial (TT) reconstructions have placed grafts in an isometric location relative to the true ACL insertion sites. Recent studies advocate the use of an accessory medial portal for more accurate placement of the femoral tunnel. Tompkins et al. reported that accessory medial portal technique placed the femoral tunnel close to the native femoral footprint, as compared to the

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TT technique. Anatomic placement of the graft closer to the femoral footprint has been shown to enhance the rotational stability of the knee.[15- 17]Hence; under the light of above mentioned data, the present study was undertaken for assessing the influence of femoral and tibial tunnel obliquity on functional outcome in arthroscopic ACL reconstruction.

In the present study, 77.4 percent of the patients belonged to the age group of 20 to 30 years. Total no of patients with the age averaged 27.13± 5.89, pre op lysholm score averaged 64.26± 8.93. At 1 year follow up. Femur tunnel coronal angle average of $37.52^0 \pm 5.04^0$ the coronal tibia tunnel was angle averaged of $72.23^0 \pm 2.44^0$.32.2% and 35.5% of patients showed grade 1 anterior drawer and Lachman test positive respectively. And mean lysholm score averaged to be 86.58±5.32. A study by Howell et al[18]. showed greater tension in an ACL graft during knee flexion when the angle of the tibial tunnel in the coronal plane is more vertical (perpendicular to the joint line). The theory that the resulting increased tension in the ACL graft could lead to stretching over time with cyclical loading and eventual anterior laxity has recently been supported by a clinical study. This study by Howell et al. suggested that loss of knee flexion and anterior laxity are greater when the angle of the tibial tunnel is greater than 75° in the coronal plane.[18]

The placement of the tibial tunnel medial to the tibial eminence causes loss of flexion and placement of the tibial tunnel lateral to the tibial eminence causes anterior laxity, it was necessary to center the tibial tunnel between the eminences in the coronal plane. An analysis of an AP or notch radiograph verified that the tibial tunnel was centered in every knee. In our study we noticed post operatively tibial tunnel placed anteriorly 21.55±4.79%($p<0.01$) and with coronal plane angle of 72.23 ± 2.44^0($p >0.01$).

Because placement of the tibial tunnel anterior to the intercondylar roof in the extended knee causes anterior laxity from roof impingement, it was necessary to position the tibial tunnel posterior and parallel to the intercondylar roof in the sagittal plane. An analysis of a lateral radiograph with the knee in full extension verified that roof impingement was prevented in every knee. Because slippage of the graft during aggressive rehabilitation can cause anterior laxity[16].

The relationship of the femoral tunnel axis with the coronal plane in our study is 37.52 ± 5.04^0 Statistical data showed that it is negatively correlated with functional outcome assessed by the lysholm score. The femoral tunnel angle and the position in the frontal and the sagittal plane were assumed to be linearly correlated to the outcome variables. The direction of femoral tunnel axis of an angle of 38.63 ± 5.13^0 showed excellentlysholm score without significant p value and negative correlation with post-operative lysholm score. The tibial tunnel axis in the coronal plane of 72.23±2.44 shows no significant correlation with lysholm score

In the present study, at baseline, according to Lyscholm score, 71 percent of the patients were of fair grade while 29 percent of the patients were of poor grade. At 2 years follow-up, according to Lyscholm score, 61.7 percent of the patients were of good grade while 12.9 percent of the patients were of excellent grade.Nema SK et al examined the radiographic location of tibial and femoral tunnels in patients who underwent arthroscopic ACLR using anatomic landmarks. 45 patients who underwent arthroscopic ACLR, postoperative radiographs were studied. Femoral and tibial tunnel positions on sagittal and coronal radiographic views, graft impingement, and femoral roof angle were measured. Radiological parameters were summarized as mean ± standard deviation and proportions as applicable. Interobserver agreement was measured using intraclass correlation coefficient. The position of the tibial tunnel was found to be at an average of 35.1% ± 7.4% posterior from the anterior edge of the tibia. The femoral tunnel was found at an average of 30% ± 1% anterior to the posterior femoral cortex along the Blumensaat's line. Radiographic impingement was found in 34% of the patients. The roof angle averaged 34.3° ± 4.3°. The position of the tibial tunnel

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was found at an average of 44.16% ± 3.98% from the medial edge of the tibial plateau. The coronal tibial tunnel angle averaged 67.5° ± 8.9°. The coronal angle of the femoral tunnel averaged 41.9° ± 8.5°. The femoral and tibial tunnel placements correlated well with anatomic landmarks except for radiographic impingement which was present in 34% of the patients.[19]

Conclusion

Statistical analysis of our data showed negative significant correlation between femoral tunnel obliquity with lysholm score.

References

1. 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.
2. Buss DD, Warren RF, Wickiewicz TL, Galinat BJ, Panariello R. Arthroscopically assisted reconstruction of the anterior cruciate ligament with use of autogenouspatellar-ligament grafts. Results after twenty-four to forty-two months. J Bone Joint Surg Am 1993;75(09):1346–1355
3. Feller JA, Webster KE. A randomized comparison of patellar tendon and hamstring tendon anterior cruciate ligament reconstruction. Am J Sports Med 2003;31(04):564–573
4. Shelbourne KD, Nitz P. Accelerated rehabilitation after anterior cruciate ligament reconstruction. Am J Sports Med 1990;18(03): 292–299
5. Bowers AL, Bedi A, Lipman JD, et al. Comparison of anterior cruciate ligament tunnel position and graft obliquity with transtibial and anteromedial portal femoral tunnel reaming techniques using high-resolution magnetic resonance imaging. Arthroscopy 2011;27(11):1511–1522
6. Lee MC, Seong SC, Lee S, et al. Vertical femoral tunnel placement results in rotational knee laxity after anterior cruciate ligament reconstruction. Arthroscopy 2007;23(07):771–778
7. Harner CD, Honkamp NJ, Ranawat AS. Anteromedial portal technique for creating the anterior cruciate ligament femoral tunnel. Arthroscopy 2008;24(01):113–115
8. Woo SL, Wu C, Dede O, Vercillo F, Noorani S. Biomechanics and anterior cruciate ligament reconstruction. J OrthopSurg 2006; 1:2. Doi: 10.1186/1749-799X-1-2
9. 9.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(03):297–304
10. Musahl V, Plakseychuk A, VanScyoc A, 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(05):712–718
11. Padua R, Alviti F, Venosa M, Mazzola C, Padua L. The influence of graft placement on clinical outcome in anterior cruciate ligament reconstruction. Joints 2016;4(01):12–16
12. Clatworthy MG, Bartelett J, Howell S et al (1999) The effect of graft fixation techniques on tunnel widening in hamstring ACL reconstruction. Arthroscopy 15(Suppl):5
13. Sauer S, Lind M. Bone Tunnel Enlargement after ACL Reconstruction with Hamstring Autograft Is Dependent on Original Bone Tunnel Diameter [Internet]. Surgery journal (New York, N.Y.). Thieme Medical Publishers; 2017 [cited 2019Oct20].
14. W. Norman scott, md,Insall and scott knee surgery 6th edition, Elsivier,2018,pp;25,26,27,28.

ISSN: 0975-3583,0976-2833 VOL13, ISSUE 01, 2022

15. Varma A, Cicotti MG. In: Outcomes of single bundle ACL reconstruction. Current concepts in ACL reconstruction. 1st ed. Freddie H, Steven B, editors. New Jersey: SLACK incorporated; 2008. p. 233.
16. Alentorn-Geli E, Samitier G, Alvarez P, Steinbacher G, Cugat R. Anteromedial portal versus transtibial drilling techniques in ACL reconstruction: A blinded cross-sectional study at two- to five-year followup. IntOrthop. 2010;34:747–54.
17. Tompkins M, Milewski MD, Brockmeier SF, Gaskin CM, Hart JM, Miller MD. Anatomic femoral tunnel drilling in anterior cruciate ligament reconstruction: Use of an accessory medial portal versus traditional transtibial drilling. Am J Sports Med. 2012;40:1313–21.
18. Stephen M. Howell, MD, Mark E. Gittins,DO, John E. Gottlieb,MD, Steven M. Traina, MD, and Timothy M. Zoellner,a MD 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):573-576
19. 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(3):286-291. doi:10.4103/ortho.IJOrtho_219_16