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Study of femoral and tibial tunnel position using CT scan, and its effect on functional outcome in arthroscopic ACL reconstruction: A prospective study

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Abstract

Background: Accurate placement of tibial and femoral tunnel has significant effect on functional outcome after anterior cruciate ligament reconstruction (ACLR). Anterior cruciate ligament tear is one of the common sports injuries, and arthroscopic reconstruction is now a day's popular surgery. Its failure is rare but not uncommon. Despite advances, failure rate after ACL reconstruction (ACLR), ranges from 0.7% to 10%[1]. Slight anterior placement of femoral tunnel can lead to restriction of knee flexion and, similarly if tibial tunnel is anterior, it leads to impingement of graft, surgical failure and also the need for a revision surgery. 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 2 year. Femoral, tibial tunnel positions on sagittal plane. 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 24 months follow up position of the tibial tunnel was found to be at an average of 31.55%±4.79posterior from the anterior edge of the tibia. The femoral tunnel was found at an average of 28.54±3.18% anterior to the posterior femoral cortex. 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: The location of femoral tunnel in the mid sagittal section from the posterior cortex 28.54±3.18% of anteroposterior length showed no significant correlation the lysholm scoring. Locating the tibial tunnel positioning on the tibial plateau from the anterior cortex of Showed significant p value with functional outcome.

Keywords: Anterior cruciate ligament, Tunnel position, obliquity, functional outcome

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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 [2-6]. Harner *et al*. introduced the anteromedial (AM) portal technique for femoral tunneling to obtain a low-oblique drilling, which should be more anatomic than the traditional transition (TT) technique [6-11].
Several studies have been conducted to identify the best location for the placement of [1] the tibial tunnel in order to ensure optimal knee functioning. Initially, researchers proposed the 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 [13]. Other studies found that an anterior placement resulted in the impingement of the graft in the intercondylar notch, causing limitations in movement [14]. Despite the large number of studies relating to the ideal placement of the graft, no clear consensus has been reached thus far.

Methods

This prospective study, conducted from MAY 2017 to JUNE 2019, reports the results of 31 cases of ACL reconstruction using hamstrings grafts that were followed up for a minimum period of 2 year. 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 hamstring tendon, measuring 10 mm, was used. Notchplasty 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 approximately 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, non-steroidal 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 for up to 2 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).

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At the end of two year a computer tomography of the knee taken femoral, tibial tunnel positions on sagittal plane. Radiological parameters were calculated with multiplanar reformation or reconstruction (MPR) that is acquired data, from the axial plane, can then be converted to non-axial planes such as coronal, sagittal or oblique. In addition, with the aid of various software, several manipulations of the data can be made and summarized as mean and standard deviation. It's measured through multiplane sections of the knee.

Sagittal section measurements

1) Its calculated as 3 parallel lines first line tangential to the anterior edge(A)of the tibia, second line center of the tunnel (C), Third line tangential to the posterior edge of the tibia () The distance between (ab) and (ac) calculated and noted and expressed as percentage of A.
2) The position of the femoral tunnel was also measured similar to the tibial tunnel from the posterior cortex to midpoint of tunnel (D) in mid sagittal section. The three tangential parallel lines first one tangential to anterior femur cortex (C), second one tangential to the posterior femoral cortex (D), third one at the center of the femoral tunnel (), the distance between the CD and C measured and noted.

The Statistical software namely SPSS 18.0 and R environment ver.3.2.2 were used for the analysis of the data and Microsoft word and Excel have been used to generate graphs, tables etc.

A comparison of the differences between the groups was done using the Student's t-test, with one-way analysis of variance for the continuous variables, while the chi-square test was applied to compare differences among the categorical variables. A multivariate analysis of variance was used to study the effect of all the compounding variables. In all the tests, an alpha level of 0.05 was considered to be significant. In our study tunnel position is found to be average of 31.55±4.79% from anterior edge of tibia. With negative correlation with lysholm score. We studied post operatively through computer tomography as percentage of anterior posterior distance from the anterior and posterior margin of tibia in mid sagittal plane. In our study, we observed a significant relationship between the tibial tunnel distance as measured from anterior margin of the tibial plateau and lysholm scores; anteriorly placed tibial tunnels within the anatomical tibial footprint site were associated with better lysholm scores. We measured the tibial tunnel position from the anterior tibial margin as we found this reference point to be consistently identifiable each time.

In our study, the femoral ACL center was found to be at an average of 28.54±3.18% anterior to the posterior femoral cortex our study did not find any significant correlations between the position of femoral tunnels and the functional outcomes over 2-year follow-up.

Fig 1

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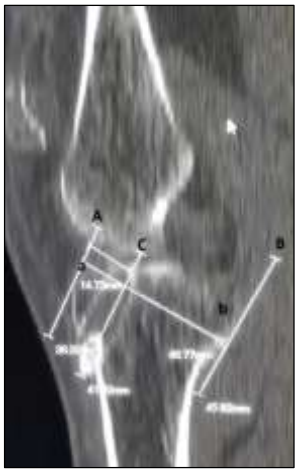

Fig 2

Table 1: Age distribution of patients studied

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: Diagnosis

Diagnosis	No. of patients	%
ACL	16	51.6
ACL+MM	15	48.4

Table 3: 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				
• 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	31(100%)	0(0%)	-100.0%	

Chi-Square test/Fisher Exact test.

Table 4: Assessment LYSHOLM SCORE at baseline and 2years

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)

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Table 5: Femoral and tibial tunnel position

	No. of patients (n=31)	%
Femoral tunnel position		
• <27	12	38.7
• 27-30	13	41.9
• >30	6	19.4
Tibial tunnel position		
• <37	29	93.5
• 37-40	0	0.0
• >40	2	6.5

Table 6: 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 7: Comparison of femoral and tibial tunnel position according to Lysholm Score 2 years

variables	Lysholm Score 2 years			Total	P value
	Fair	Good	Excellent		
FE TU PO	27.24±1.50	28.84±3.47	28.88±3.64	28.54±3.18	0.553
TB TU PO	36.61±8.02	30.29±3.84	30.56±3.09	31.55±4.79	0.011*

ANOVA test

Table 8: Pearson correlation of position, obliquity with lysholm score

Pair	r value	P value
LYSHSCOM 2 years vs. FE TU PO	0.122	0.513
LYSHSCO2 years vs. TB TU PO	-0.441	0.013*

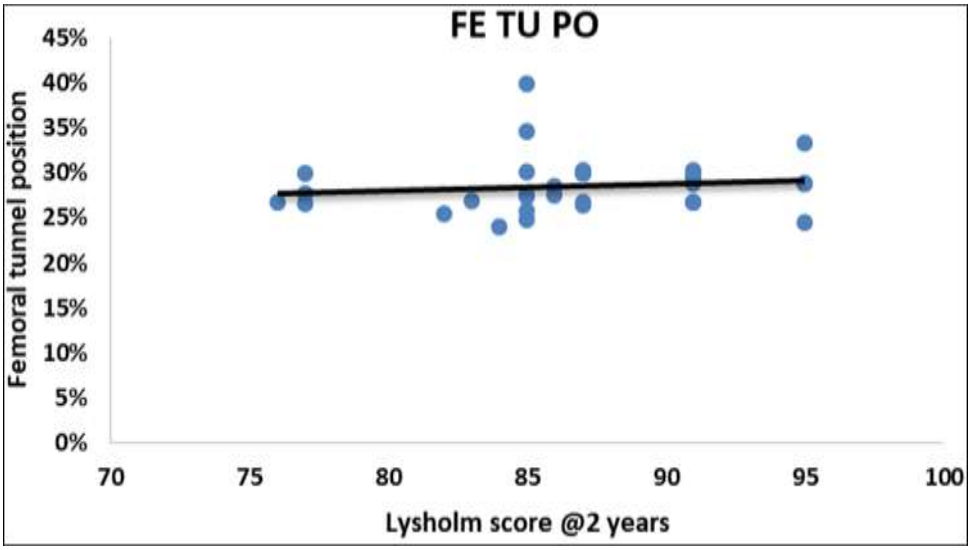

Fig 3: Scatter plot of femoral tunnel position

ISSN 2515-8260 Volume 09, Issue 02, 2022

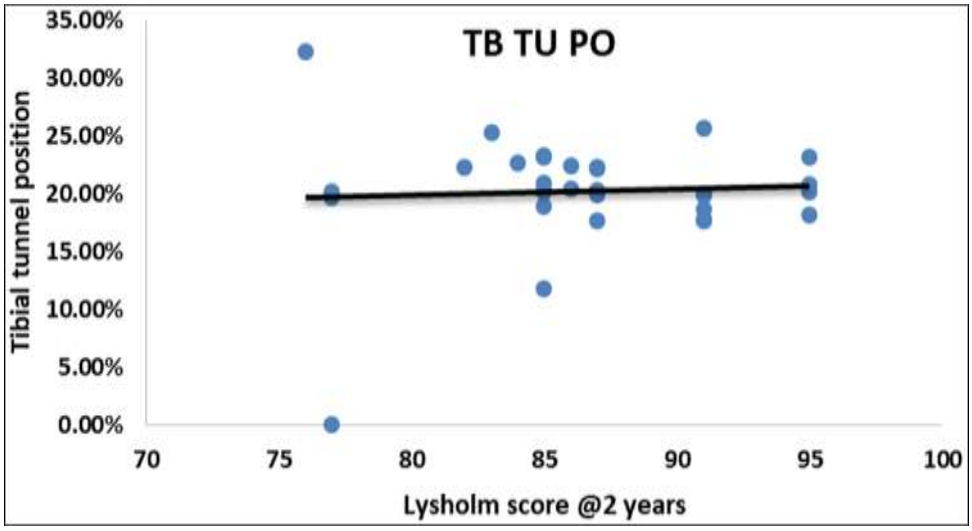

Fig 4: Scatter plot of tibial tunnel position

Discussion

The position of the tibial tunnel is a strong predictor of the outcome of ACL reconstructions. Preventable complications such as anterior knee pain, effusions, extension loss and recurrent instability can occur when the tibial tunnel is improperly placed and the roof and notch plasty are insufficient. In our study tunnel position is found to be average of 21.55±4.79% from anterior edge of tibia with negative correlation with lysholm score.

A previous study that investigated the ACL foot prints using 3D-CT found the tibial origin of ACL to vary between 9.3 and 13.1 mm [15] as measured from tibial inter tubercle ridge to the anterior fibers of the ACL. While our values are found to be different from the above study, the difference in values could be attributed to the differences in reference point of measurements.

Despite the efforts to place the tibial tunnel in this ideal position, it is possible that the tibial tunnel could be placed either anterior or posterior in relation to the native footprint. We studied post operatively through computer tomography as percentage of anterior posterior distance from the anterior and posterior margin of tibia in mid sagittal plane. In our study, we observed a significant relationship between the tibial tunnel distance as measured from anterior margin of the tibial plateau and lysholm scores; anteriorly placed tibial tunnels within the anatomical tibial footprint site were associated with better lysholm scores. We measured the tibial tunnel position from the anterior tibial margin as we found this reference point to be consistently identifiable each time.

Lee *et al*. conducted an *in vivo* 3D evaluation of tunnel position after single bundle ACLR using AAMP. The quadrant method for evaluation of height and depth of the tunnels was used in the above study and the center of the tibial tunnel in their study was located at 44.6% ± 2.5% from the anterior margin and 48.0% ± 3.0% from the medial margin [16]. In a recent study, Yang *et al*. found the tibial tunnel to be located at 45.43% ± 4.81% from the anterior margin of the tibia [16]. While both the above studies reported similar results with regard to the depth of tibial tunnel positions, we could not compare these results with our study as we did not employ the quadrant method to describe the tunnel position depth.

A direct comparison of the results is not possible since we did not use the quadrant method to quantify the tunnels. Where we used a simple method, values were in agreement with most of the studies that used the quadrant method to quantify the femoral tunnels.

The AM portal technique allows more anatomic femoral tunnel position when compared to the TT technique. In a single-bundle ACLR as the one we used in our study, the goal is to place the tunnels at center of the ACL footprints which is assumed to be located in the middle

ISSN 2515-8260 Volume 09, Issue 02, 2022

between the AM bundle and the posterolateral (PL) bundle. term in our study, the femoral ACL center was found to be the femoral tunnel was found at an average of 28.54 ±3.18% anterior to the posterior femoral cortex Our study did not find any significant correlations between the position of femoral tunnels and the functional outcomes over 2-year follow-up. Various studies report excellent short-term outcomes as measured by IKDC, Lysholm, and Knee stability tests with anatomical tunnels placed with AM portal technique. However, there is still debate as to whether this changes the long-term clinical outcomes for the patients, as a recent cohort study with 5 years follow-up found no significant difference in terms of long function [18].

Several methods of evaluation of tunnel positions have been described in literature which includes the Quadrant method, Watanabe method and Takahashi's method. All these methods are assessed with plain radiographs [17, 18, 19].

To conclude, the location of femoral tunnel in the mid sagittal section from the posterior cortex of anteroposterior length showed no significant correlation the lysholm scoring. Locating the tibial tunnel positioning on the tibial plateau from the anterior cortex of Showed significant p value. And significant correlation with functional outcome.

We employed simple method of measuring the tunnel position in percentage of distance from identifiable bony landmarks and expressed in ratio. This made direct comparison of our results with several existing literatures difficult. However, we believe that employing bony landmarks as reference points to quantify tunnel positions could be more useful and easier to reproduce.

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Conflicts of interest: There are no conflicts of interest.

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