ORIGINALARTICLE

Computed Tomography Assessment of Tibial Tunnel after Arthroscopic Anterior Cruciate Ligament Reconstruction

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Abstract:
Background: Knee injury becoming a common sport related injury of which anterior cruciate ligament (ACL) Injury is the most common. The graft placement at anatomical position is a major challenge during arthroscopic surgery. Three-dimensional (3D) reconstruction of computed tomography (CT) images is currently the best method to determine whether the ACL tunnel and grafts positioned correctly. The aim of this study is to assess the anatomical tibial tunnel positioning in patients after arthroscopic ACL reconstruction using CT scans. Material and Method: This wasa prospective study carried out over a period of 1 year on 39 patients in the age group of 19-52 year who underwent arthroscopic ACL reconstruction. Results: The tibial tunnel diameter between 7.5-8.5 mm and length of 3-4 cm and tibial tunnel - coronal angle of 55-65degree and sagittal angle of 40-50 degree was found in most of the patients. Most patients had position of tibial tunnel along anterior to posterior axis of 32-40% and position of tibial tunnel along medial to lateral axis of 44 to 50 %.Tibial tunnel position along high to low axis and deep to shallow axis were non-anatomical. Conclusion: Low percent of ACL reconstruction were in recommended anatomical position. CT scan is a very good tool to analyse tunnel position after ACL reconstruction.

Keywords: ACL ,3D-CT scan, arthroscopy, tibial tunnel.

Introduction:

The knee joint is the most commonly injured of all joints.(1) Anterior Cruciate ligament (ACL) acts as the primary stabilizer of the knee and to prevents the knee against anterior translation.(2)It is also important in counteracting rotational and valgus stress.(3)Arthroscopic ACL reconstruction is the most preferred surgery for ACL tear nowadays.(4)The major challenges in ACL reconstructionist to place the graft in anatomical position. The rationale behind anatomic ACL Reconstructionist to improve joint laxity and prevent degeneration of cartilage. (5)The concept of anatomic ACL reconstruction advanced at the beginning of the 21st century. Biomechanical studies suggested more normal biomechanics and graft tension patterns when placing tunnels in the footprint of native ACL.(6-8) Nowadays, the importance is given to anatomical graft placement to create more accurate knee kinematics.(9) The clinical studies have shown advantages with regard to the stability gained with the more anatomical position of the femoral tunnel.(10,11) The poor outcome has been noted when there is non-anatomical graft placement. (4)It is estimated that more than 80% of failure has been attributed to this non-anatomical placement. (12)Currently the best method to determine whether the ACL tunnel and grafts positioned correctly is by 3-dimentional computed tomography (3-D CT SCAN). (13,14)

Material and Methods:

The study was an observational study conducted at a tertiary level hospital on patients treated arthroscopically for ACL injuries over a period of 1 year. Isolated ACL tears with or without associated meniscal injuries in age group of 18-52 years was included in the study. Exclusion Criteria included: In posterior cruciate ligament injury, Medial and lateral collateral ligament injuries, ACL re-injury, Ipsilateral distal femur or proximal tibia fracture and Revision surgery. In the study,39 patients were included according to the above criteria. After taking informed and written consent of the patients, immediate post-operative CT scan with 3D reconstruction using 128slicesof all the patients were done and assessed. The OsiriX software was used to calculate the tibial tunnel length, diameter, angle and position. All the data was entered and compiled in MS Excel and was analysed using Statistical Package for Social Sciences (SPSS, Inc., Chicago, Illinois).Arthroscopic ACL reconstruction was performed. Post-operative CT scans (within 10 days) of the patients were done. Aim of this study was to assess the placement of tibial tunnel after arthroscopic ACL reconstruction through post-operative CT scan. Data collection included age, sex and CT scan findings of tibial tunnel measurements using 3D reconstruction images. Subtracting the femur, fibula and patella digitally in 3D mode was done in all cases. The parameters of the tibial tunnel recorded were Tibial tunnel diameter (image 1), Tibial tunnel length (image 2), Tibial tunnel position innate-posterior (AP) and medio-lateral (ML) using Quadrant method. (Image 3), Angle formed by tibial tunnel with the medial tibial plateau in the coronal plane. (Image 4) and Angle formed by tibial tunnel with the anterior tibial plateau in the sagittal plane. (image 5)

Results:

Tibial tunnel diameter: The average calculated diameter of the tibial tunnel was 7.903 mm while the smallest and largest of the tunnel diameter were 5.914mm and 9.955mm.The maximum tunnels were in the range of 7.5-8.5mm (18tunnels outof39-48.15%). (Table-1)

Table no.1 Tibial tunnel diameter

Tibial tunnel Diameter (mm)	Frequency	%
5.5-6.5mm	1	2.56
6.5-7.5mm	11	28.21
7.5-8.5mm	18	46.15
8.5-9.5mm	8	20.52
>9.5mm	1	2.56
Total	39	100
Mean tibial tunnel Diameter=7.903mm		

Table no.2 Tibial tunnel length

Tibial tunnel length(cm)	Frequency	%
2-3cm	13	33.33
3-4cm	25	64.11
>4cm	1	2.56
Total	39	100
Mean Tibial tunnel Length=3.21cm		

Table no.3 Angle in coronal plane (coronal angle)

Angle in Coronal plane	Frequency	Percent
<55	2	5.13
55–65 (Recommended range)	23	58.98
65–70	8	20.51
>70	6	15.38
Total	39	100
Mean angle in coronal plane=63.415degree		

Table no.4 Angle in sagittal plane (sagittal angle)

Angle in sagittal plane (In degrees)	Frequency	%
<40	1	2.56
40–50	18	46.15
50-60	18	46.15
>60	2	5.14
Total	39	100
Mean angle in sagittal plane = 50.9395 degree		

Table no.5 Measurements along Anterior to posterior axis

Position of tunnel along anterior to posterior axis (in percentage)	Frequency	%
<32.5%	5	12.82
32.5to 40.1% (Recommended range)	19	48.72
>40.1%	15	38.46
Total	39	100
Mean percentage of tibia tunnel along anterior to posterior axis= 40.41%		

Table no.6 Measurement along medial to lateral axis

Position of tunnel along medial to lateral axis(in percentage)	Frequency	%
<44.3%	1	2.56
44.3to 49.7% (Recommended range)	33	84.62
>49.7%	5	12.82
Total	39	100
Mean percentage of tibia tunnel along medial to lateral axis= 47.16%		

Table no.7 Tibial tunnel position along anterior to posterior axis and medial to lateral axis

Tibial tunnel position along anterior to posterior axis and medial to lateral axis	Frequency	%
Anatomical	17	43.59
Non-anatomical	22	56.41
Total	39	100.0

Tibial tunnel length: The tunnel length varies from 2.47cmto4.07 cm with meanlengthof3.21 cm. Thirteen patients were in the range of 2-3 cm (33.33%) and 25 were in the range of 3-4cm (64.11%) while only 1tunnel was more than 4cm in length. (Table-2) Angle in coronal plane (coronal angle)–The mean angle in coronal plane was 63.415 degrees with the smallest value of 52.487 degrees and maximum of 75.664degrees. Two tunnels were less than 55 degrees, 23 were in the recommended anatomical range of 55 to 65 degrees (58.98%), 8 in the range of 65 to 70 degrees while 6 were more than70degrees. (Table -3) Angle in sagittal plane (Sagittal angle) –The average calculated sagittal angle was50.9395 degree. With the minimum and maximum value of 38.868 degrees and 63.215degree respectively. There were 18 tunnels each in the range of 40-50 degree and 50-60degree. (Table -4) Quadrant method: a) Measurements along Anterior to posterior axis - The average total anterior toposteriorlengthwas47.95 mm. The smallest and largest calculated lengths were 39.7 mm and 56.81 mm respectively. The average distance of centre of tibial tunnel from anterior end along the anterior to posterior axis was 18.40 mm. The mean percentage at which tibial tunnel was position calculated along anterior toposterioraxiswas40.41%.The anterior most of the tunnel was placed at 20.04% and posterior most of the tunnel was placed at 50.97%alongtheanterior to posterior axis. Nineteen tunnels were in the recommended anatomical range of 32.5% to 40.1%, 5 had a value of less than 32.5% and 15 had value of morethan40.1%. (Table -5) b) Measurements along Medial to lateral axis –The average calculated total length along medial to lateral axis was 72.47 mm. The minimum and maximum calculated lengths were 62.82 mm and 85.75mm respectively. The average length at which tibial tunnel was placed along the medial to lateral axis counting from medial to lateral was 28.77 mm. The mean percentage at which tibial tunnel was placed along medial to lateral axis was 47.16%. Out of 39 tunnels evaluated, 33wereinthe recommended range of 44.3 to 49.7%. (Table-6) c) Tunnel position in both anterior to posterior and medial to lateral axis: Considering tunnel placement in both anterior to posterior axis and medial to lateral axis, 17 tunnels out of 19 were in recommended anatomical position. Hence 43.58%of the total tibial tunnels were in the recommended anatomical position. (Table -7)

Image 1: Tibial tunnel diameter measurement

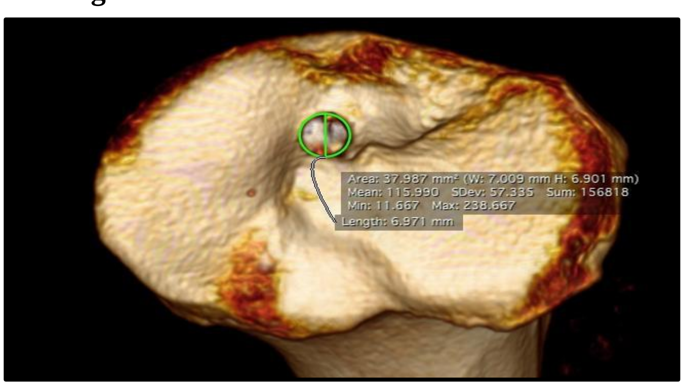

Image 2: Tibial tunnel length measurement

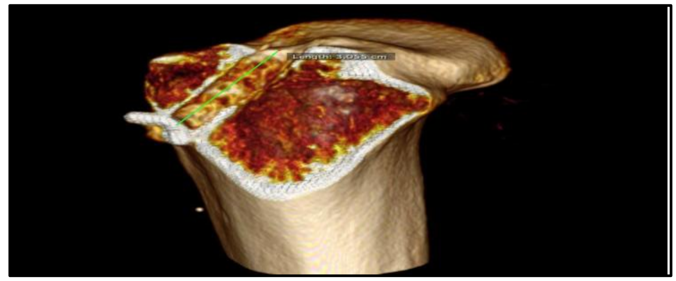

Image 3: Measurement of tibial tunnel position using Quadrant method

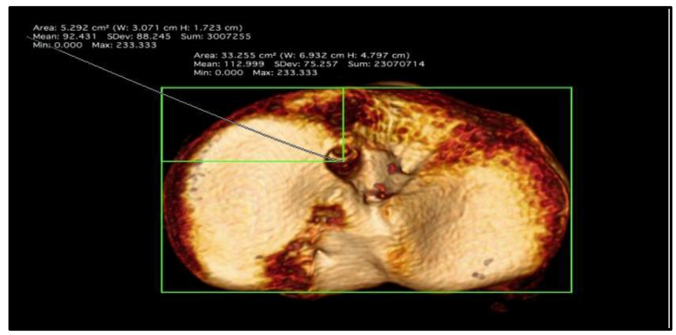

Image 4: Measurement of tibial coronal angle

Image 5: measurement of tibial sagittal angle

Discussion:

In present study, 39 post-operative patients were evaluated for tunnels placement using CT-scan in immediate postoperative period which is comparable to study by Lee et al.(15) S. Kopf et al.(16)where 32 patients were evaluated each; in study by Ghaffar et al.(17) 35 patients were studied and J. H. Bird et al. (18)

studied 50 cases of ACL reconstruction. While study done by T. Vermersch et al.(19) evaluated 16 patients who went under partial ACL reconstruction and 180 patients who underwent complete ACL reconstruction and F. Bus caret et al. (20)studied 99 patients by post-operative CT scans. The average age in this study was 31 years which was similar to study done by Lee et al.(15), S. Kopf et al.(16), J. H. Bird et al. (18), T. Vermersch et al.(19)and Buscayret et al. (20)where mean age were 31.9 years, 35.1 years, 30years ,33 years and 28 years respectively. When sex of the patients is considered, out of 39 patients, 30 of the patients (76.92%) were male while 9 (23.08%) were females with a male to female ratio of 3.33:1. This pattern is also seen in studies done by Lee et al. (15), S. Kopf et al. (16), J. H. Bird et al. (18)Ghaffar et al.(17) where male: female patients were 26:6 , 22:8, 29:6 and 38:12. On the contrary, study done by F. Buscayret et al.(20)had 58 male and 41 female patients. In this study also, male subjects were more but the ratio was less. In the present study, left side ACL tears were more as compared to right side (17 of right knee and 22 of left knee ACL tear). Similar findings were in the study of Lee et al.(15)where 15 right and 17 left knee ACL tears were noted. On the other hand, 53 Ghaffar et al.(17)(right knee-26, left knee-9) and J. H. Bird et al. (18)(right knee-28, left knee-22) reported higher number of right side cases as compared to left side. The average calculated diameter of the tibial tunnel was 7.903 mm with 18tunnels out of 39 in the range of 7.5-8.5mm (48.15%) followed by 11 tunnels in the range of 6.5-7.5mm (28.21%). As in femoral tunnel, here also it correlates with the clinical experience of 8mm drill bitbeing most commonly used for drilling of thetunnelfollowedby7mm drillbit. The tunnel length had values from 2.47cm to 4.07cmwith average length of 3.21 cm. 13 patients were in the range of 2-3 cm (33.33%) and 25 were in the range of3-4 cm (64.11%) while only 1 tunnel was more than 4 cm in length. No literature found on study of diameter or length of the tibial tunnel. The radiographic checkpoint for determining whether the angular placement of the tibial tunnel guide wire is correct is the formation of a 60° to 65° angle between the tibial tunnel guide wire and the medial joint line. (21-24) If the angle is >70°, thenthefemoraltunnelwillbetooverticalandthefemoraltunnelwillcausePCLimpingement.(21-24)In the present study, the average calculated sagittal angle was 50.9395 degree with 18 tunnels each in the range of 40-50 degree and 50-60 degree. The average angle in coronal plane was 63.415 degrees with 23 out of 39 were in the recommended anatomical range (58.98%). C. Topliss et al.(25)reported 28% of the tunnels out of acceptable criteria in coronal plane. In a study by E. Inderhaug et. al.(26)in 2014, Sagittal and coronal radio graphs were performed to assess tibial tunnel placement. On sagittal radiographs, the Placement of the tunnel was measured along the Amis and Jackob (AJ) line, and posterior tibial tunnel placement was defined as 50% or more of the AP-distance. On coronal radiographs the inclination of the tibial tunnel was measured as the angler lative to a line across the tibial plateau, and defined as steep if found to be 75 degrees or more in inclination. Potential relations between clinical findings, subjective scores (Lysholm and IKDC subjective) and radiological parameters were explored. Results showed mean tunnel placement along theAJ-linewas46%andthemeantunnelinclination was 71 degree. 24% of all patients had a posterior tunnel positions assessed in the AJ-line, and 14% had a steep tunnel inclination as assessed in the coronal plane. They found no differences in subjective scores when comparing sagittal and coronal tunnel placement considering anterior versus posterior and steep versus normal tunnel placements. A significant difference was, however, found between anterior and posterior tunnel placement– with a higher incidence of 2+ pivot shift in the posterior tunnel group. They concluded that patients a high incidence of posterior tibial tunnels, were found to have more rotational instability (2+ pivot shift) withassociatedinferiorsubjectivescoresthanpatientswithnormalrotational laxity. In the present study, the mean percentage at which tibial tunnel was position calculated along anterior to posterior axis was 40.41%. Only one patient had value of more than 50%. Nineteen tibial tunnels were in the recommended anatomical range of 32.5%to40.1%.S. Kopf et al. (16) in 2010, reported tibial tunnels at a mean of 48.0% ± 5.5% oftheanterior-to-posteriorplateaudepthandameanof47.8%±2.4%ofthemedial-tolateral plateau width. Tibial tunnels were position remedial to the anatomic poster lateral position in their study, they reported. In present study, mean anterior to posterior position was 40.41% and mean medial to lateral position was 47.16% which is anterior to the findings of S. Kopf et al. Considering tibial tunnel placement in both the anterior to posterior axis and medial to lateral axis, 17 tunnels out of 19 were in recommended anatomical position (43.58%). In the present study, when considered individually, 9 femur tunnels and 17 tibialtunnelswereinrecommendedanatomicalposition.Whenthereconstructionisconsidered as a whole (femur and tibia tunnel position is considered simultaneously), 10% subjects had both femur and tibial tunnel in recommended anatomical position,46% had either femoral tunnel or tibial tunnel in anatomical position. 17 of the subjects (43.49%) had none of the tunnel in recommended anatomical position. Conclusion: In the present study,9 out of 39 tibial tunnels were in the recommended anatomical position. CT scan is a very good tool to analyse tunnel position after ACL Reconstruction. Feedback from CT scans may help surgeons to improve in future surgeries.

Sources of supports: Nil

Conflicts of Interest: Nil

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