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Original Article

Does the position of interference screw in tibial tunnel effect anatomic orientation in single bundle anterior cruciate ligament reconstruction?

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ABSTRACT

Background/objective: The purpose of the study was to evaluate the change in orientation of the reconstructed ACL with the change in position of the interference screw in the tibial tunnel.
Method: It was a retrospective review of Magnetic Resonance Imaging (MRI) in which 51 normal and 61 MRI of patients who had undergone ACL reconstruction at our institute were evaluated. Postoperative ACL reconstruction group MRI studies were obtained and evaluated by two sports medicine fellows independently to assess the position of interference screw, distance of the graft from the anterior cortex of tibia and inclination of the graft. The data was collected and compared with MRI data of normal ACL patients.
Results: There were total 61 patients with ACL reconstruction. 32 patients had anterior screw placement and 29 patients had posterior screw placement in the tibial tunnel. The distance of the graft from the anterior cortex was 39.18% in ACL intact group, 50.35% in anterior screw group and 41.64% in posterior screw group. The inclination angle was 44.49º in intact group, 49.69° and 42.20° in anterior and posterior screw group respectively. The difference between intact group and anterior screw group was statistically significant.
Conclusion: Posterior position of interference screw in tibial tunnel increases graft obliquity than anterior position and decreases its distance from the anterior tibial cortex. This increased graft obliquity and distance from the anterior tibial cortex is similar to the native ACL.

Introduction

Reconstruction surgery for anterior cruciate ligament (ACL) has a long history. Since the first report in 1837 it has evolved and developed from extra-articular stabilization to intra-articular anatomic single/double bundle reconstruction, from tensor fascia lata to allograft, from outside in to all inside and is still evolving. This was possible because of better understanding of the anatomy and kinematics of the knee, advances in the objective clinical evaluation methods, advances in technology and long term follow up results. Today the most accepted method is arthroscopic all inside anatomic ACL reconstruction. The anatomic ACL reconstruction aims at functional restoration of the ACL to its native dimensions, collagen orientation and insertion sites.[1] It is important to note that anatomic ACL reconstruction focuses on native dimensions, orientation and insertion sites. Siebold et al. showed that the tibial attachment of ACL is a flat 'C' or a 'ribbon shaped' with no central or postero-lateral insertion fibres.[2]

Even if the anatomic foot prints are correctly chosen for the tibial and femoral tunnels does the position of interference screw in the tibial tunnel alter the ACL orientation? This question has not been addressed much in the literature. Keeping this is mind we hypothesized that the position of interference screw in the tibial tunnel would alter the graft orientation in anatomic ACL reconstruction. The purpose of this study was to compare graft orientation and inclination angle with postero-lateral and antero-medial interference screw position in tibial tunnel in aperture fixation techniques.

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Methods and materials

It was a retrospective study in which a review of magnetic resonance imaging (MRI) of patients with ACL reconstruction was compared to MRI in which ACL was intact. The hospital data of all the ACL reconstructions done from January 2013 to December 2018 were obtained. On reviewing the MRI of the patients we found that some patients had screws anterior while some had screws posterior to the graft in the tibial tunnel. The patients were then pooled into two groups i.e. 'Anterior' and 'Posterior' groups based on the position of the screw in the tibial tunnel. Our inclusion criteria were: 1) patients with isolated ACL injury who underwent ACL reconstruction surgery using quadrupled hamstrings graft and operated by a single senior surgeon, 2) Availability of both pre-operative and post-operative MRI for assessment and 3) No history of trauma in the post-operative or rehabilitation period. Our exclusion criteria were 1) concomitant bony or other ligament injury to the same knee, 2) history of previous surgery to the same knee, 3) Revision ACL reconstruction surgery, 4) surgery done at other centre or by other doctors at our institute and 5) Pre-operative and/or post-operative MRI not available. The MRI of ACL intact group was included only after a musculoskeletal radiologist had reported that ACL was normal and no other ligament injury was present. The indication of MRI in these patients was chronic knee pain. A total of 228 ACL reconstructions which were done by a single surgeon were considered for the present study. Of these 76 (associated with meniscus tear), 23 (underwent corrective osteotomy), 19 (associated with collateral ligament injury), 21 (multi-ligament injury), 7 (revision ACL reconstruction), 12 (grafts other than hamstrings were used) and 9 (did not have post operative MRI) were excluded from the study. Thus, we were left with 61 isolated ACL reconstruction patients who met our criteria and were included in the study. During the same period we had MRI of 51 normal knees.

A cross check of operative records of these 61 patients was done to ensure that only ACL was injured and reconstruction done by single surgeon using quadrupled hamstring graft. The hamstring graft was harvested from ipsilateral leg. The graft was quadrupled. Femoral and tibial tunnels were made at the foot prints according to the diameter of the graft. Tibial tunnel was over reamed by one size up while femoral tunnel was reamed of the same size of the graft. Femoral fixation was done by endo-button. After tensioning the graft it was fixed in the tibial tunnel with interference screw.

Of the 61 patients in ACL reconstruction group we had 32 patients with anterior screw placement (Fig. 1A) and in 29 patients the screw was posterior to the graft (Fig. 1B). The post operative MRI of the ACL reconstructed patients were obtained at six to nine months after the surgery.

From post operative MRI mid sagittal section in the extended knee was obtained. We assessed the antero-posterior tibial insertion of ACL as shown by Staubli and Rauschning.[3] The distance of the centre of the tibial attachment area of the ACL from the anterior tibial margin was measured (Fig. 2A). This was expressed in percentage of the total antero-posterior width of tibia. The inclination angle was measured by drawing a perpendicular to the axis of tibia and the angle it made to the long axis of the graft (Fig. 2B). The measurements were obtained by two fellows in the sports medicine department of our institute separately.

The data were described using descriptive statistics including mean, standard deviation (SD), number and percentage. One-way Anova was used to compare continuous variables between three groups of patients and Independent T Test was used to compare continuous variables between two groups. Comparison of categorical variables was performed using Chi-square test. The inter-observer variability was assessed by intra class correlation coefficient (ICC). A p-value of ≤ 0.05 was considered statistically significant. Statistical analyses were performed using SPSS version 18.0.

Results

We had a total of 112 patients who were included in the study. There were 51 patients in the normal group, 32 patients in the anterior group and 29 in the posterior group. The mean age in years of the patients in all the groups is shown in Table 1. There is a significant difference in the mean age when the normal group is compared to anterior group or the posterior group (p value 0.001). But the mean age is not statistically different when the anterior and the posterior groups are compared.

The mean value of the position of the graft is expressed in terms of percentage from the centre of the graft to the anterior tibial margin with respect to the total antero-posterior width of tibia. The mean anterior distances are 50.35 ± 3.91, 41.64 ± 6.82 and 39.18 ± 4.93 for anterior screw group, posterior screw group and normal group respectively. There is a statistically significant difference in the distance of the graft position in anterior screw group when compared to the normal group. The difference however is not statistically significant in the posterior screw group and the normal group (Table 2).

On evaluation of the inclination of the reconstructed graft and the normal ACL inclination angle on the sagittal film we found that the mean angle in the posterior screw group was similar to the normal group. However, there was a statistically significant difference between the anterior screw group and the normal group (Table 2).

The intraclass correlation coefficient showed that the inter-observer reliability was good. It's values were more than 0.9 in all the measurements (Table 3).

Discussion

It has been shown in the literature that the placing the graft in the anatomical foot prints in tibia and femur makes the graft anatomic. This takes care that the graft is not vertical and closely resembles the normal graft orientation. As our study includes MRI of patients operated by a single surgeon, we believe that variability in the position of the tibial and femoral tunnels are less likely. Thus, we are of the opinion that the inclination of the tibial tunnel was similar in both the groups for two reasons. Firstly, the technique of making the tunnel is same in all the patients and secondly, as already mentioned the tunnels were made at the foot print of tibial and femoral attachment of ACL. However, our study shows that fine tuning of the graft orientation to match the normal anatomy can be brought about by placing the interference screw postero-laterally in the tibial tunnel. This screw placement pushes the graft anteriorly and medially. The screw is placed in the tunnel so that the tip of the screw just reaches the articular surface. The screw tip is thus at the articular opening of the tibial tunnel. This ensures that the whole graft from the aperture itself is antero-medial to the screw. If the screw tip is not placed till the opening of the tunnel, the distal part of the graft will be anterior to the screw while the proximal part will cover the posterior part of the tunnel as well. This screw placement decreases the distance of the graft from the anterior tibial margin. At the same time it decreases the inclination angle of the graft i.e. makes the graft more oblique (Fig. 1 A and B). Illingworth et al. showed that the normal ACL inclination angle ranges from 43° to 57° in sagittal-view magnetic resonance (MR) reconstructions.[4] Anteriorly placed screws have the disadvantage of being proud at the proximal tibia more commonly than not (Fig. 3). This is because the tunnel is usually smaller in length when the screw is placed anteriorly. However, when the screw is placed

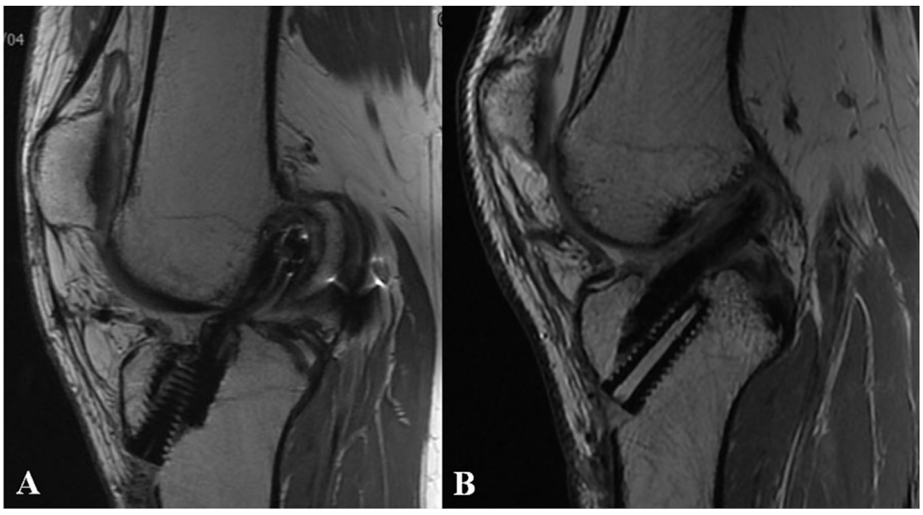

Fig. 1. Shows the MRI image of the ACL reconstructed knee with screws anterior **(1A)** and posterior **(1B)** to the graft. The inclination of the graft and the distance of the graft from anterior tibial cortex can be noted and compared clearly in the two images.

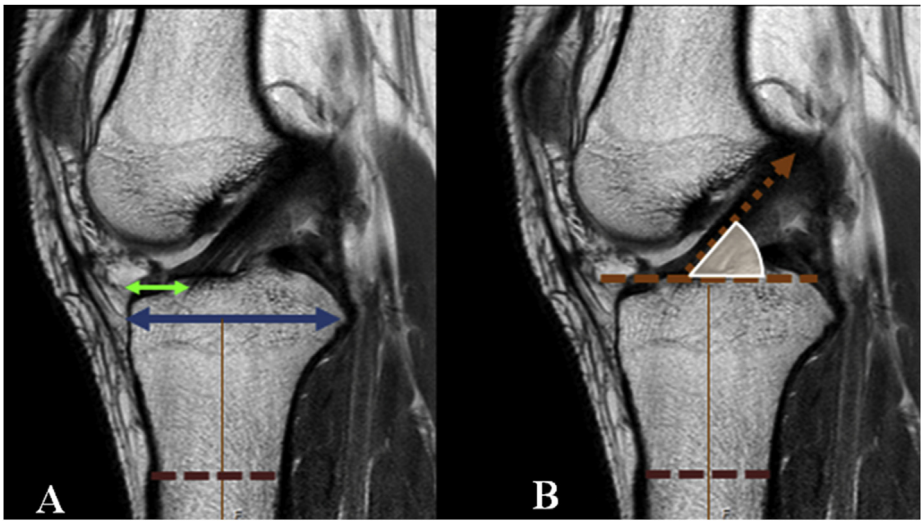

Fig. 2. Shows mid sagittal MR image of a normal knee. Lines are drawn on the image to show how the distance of the graft was calculated from the anterior tibial cortex **(2A)** and **(2B)** shows how the inclination angle was calculated.

Table 1
Age of patients in different Groups. It shows that the p value between mean age of Anterior and Posterior group is not significant (†) while that of normal group and the operated groups is significant (*).

Characteristics	Mean Age (years)	P value
Anterior	32.09±9.43	
Posterior	34.83±9.90	†0.274
Normal	41.49±12.81	*0.001

Table 3
Intraclass correlation coefficient of the two observers. It shows that ICC values in all the 3 groups for both the graft position and graft angle is >0.9. It implies that the inter observer reliability is good.

Characteristics	Anterior	Posterior	Normal
Graft Position %	0.99(0.98-1.0)	0.97(0.93-0.98)	0.96(0.93-0.98)
Graft Angle	0.98(0.96-0.99)	0.96(0.92-0.98)	0.97(0.95-0.98)

Table 2
Distance of ACL from anterior Tibial Margin and Inclination Angle of graft in sagittal plane in all the three groups.

Characteristics	Anterior Group	Posterior Group	Normal Group	P Value
Mean Distance from anterior Tibial Margin	50.35±3.91 *	41.64±6.82	39.18±4.93 *	<0.001 *
Mean Sagittal Plane Graft Incllination Angle	49.69±5.34 *	42.20±4.12	44.49±4.73 *	<0.001 *

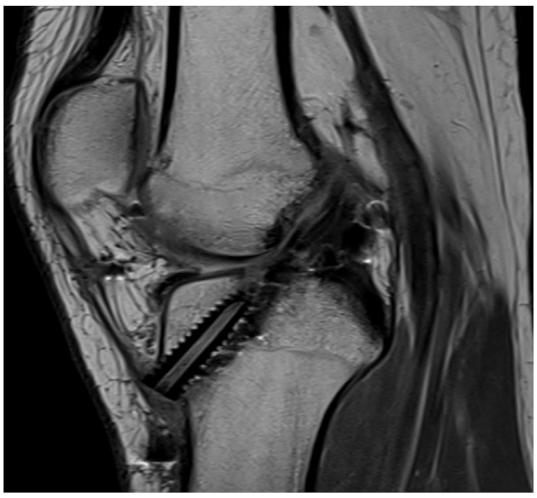

Fig. 3. Shows the MRI image of an ACL reconstructed knee with screw placed anterior to the graft. It also shows that the screw is proud at proximal tibia.

posterior to the graft the tunnel length is sufficient to accommodate the screw completely.

There is a statistically significant difference between the age in reconstruction groups and the normal group in our study population. There was however, no difference in the age group when the reconstruction groups were compared. Moreover, we studied only the radiological orientation of the graft and not the clinical outcome. We thus believe that this difference in the age groups would have no effect on our observation.

Most authors agree that the position of the graft in ACL reconstruction is important for normal knee function and kinematics. We are not aware of any research in which the effect of position of interference screw in the tibial tunnel on the graft orientation has been studied. There are, however, many studies which have considered the graft obliquity based on the technique of making tunnels e.g. trans-tibial (TT), Antero-medial (AM) and Inside out (IO).

Lee et al. in their meta-analysis found that graft obliquity is affected by the location of intra-articular tibial and femoral apertures.[5] They found that there was no significant difference in sagittal plane graft obliquity based on the drilling techniques. The coronal obliquity of the femoral tunnel was however, more using antero-medial and outside in techniques than the trans-tibial technique.

Guler et al. in their study found that both the trans-tibial and antero-medial tunnel techniques were anatomical.[6] They found that ACL graft was more vertical in trans-tibial technique than the antero-medial technique with mean sagittal angle being 58.87° and 57.78° respectively ($p < 0.001$). The distance from the anterior tibial margin was 0.51% in both groups. In the non-operated group the sagittal angle was 46.80° in AM group while it was 47.38° in TT group. The distance from anterior tibial margin in non operated groups was same in both groups which was 0.48%. However, both these techniques did not match the native ACL graft orientation. They attributed this to the anterior screw placement in the tibial tunnel and concluded that antero-medial technique was superior to the trans-tibial technique.

Budny et al. showed that the surgeons opted to make tibial tunnel more posterior than they made 5 years back.[7] Also on the femoral side there was a shift to make the tunnel more inferiorly than previously done. These changes make the graft more oblique and more anatomically oriented.

Parate and Chernchujit developed a surgical technique in which they showed how to place the screw postero-laterally in the tibial tunnel.[8] They found that putting the screw postero-laterally in the tibial tunnel makes the graft more oblique.

Vermesan et al. in their retrospective study showed that the mean sagittal graft angle was 54.5° in antero-medial technique and 63.68° in trans-tibial technique.[9] We did ACL reconstruction using antero-medial technique. Our mean values do not match with the values of Vermesan et al. This may be because in their study more than one surgeon performed the surgery, graft choices and fixation methods were also different. They made comparison in the two reconstructed group only and did not compare with normal ACL patients.

Araujo et al. in their cadaveric study calculated the mean sagittal inclination angle in ACL intact knee and ACL reconstructed knee.[10] In the reconstruction group they kept the tibial tunnel fixed at the anatomical foot print but on the femoral side they made three tunnels at different location. They found that the mean angle in the intact knee was 51.7 ± 5.0°. In our study we found the mean sagittal angle in intact knee to be 44.49 ± 4.73°. Both the values were in normal range as shown by Illinworth et al.[4] Their value for the anatomic reconstruction was 51.6 ± 4.1° which was different from our values. The post reconstruction difference between our values and their values may be due the fact that they used post fixation on both the sides. They concluded that the anatomic ACL reconstruction has a lower graft inclination angle than that of non-anatomic reconstruction and the mid inclination angle was closer to the native ACL inclination angle.

Andrei et al. compared the mean sagittal angle in ACL reconstruction patients with that of the contra-lateral knee of the same patient.[11] Tibial and femoral tunnels were drilled at the anatomic footprint. They found that the mean sagittal angle in the operated knee was 52.6 ± 2.9° as compared to 51.9 ± 1.95°. The p value was 0.051.

Zampelli et al. stressed upon the importance of coronal obliquity concluding that a more oblique graft in coronal orientation controlled tibial rotation better than a vertical graft.[12] They, however did not find any relationship with a sagittal graft obliquity. Mall et al. concluded that knee stability provided by the obliquity of the graft in ACL reconstruction was particularly sensitive to tibial tunnel placement.[13]

There are a few limitations of our study. It was a retrospective study with a relatively small sample size. We only considered MRI evaluation of the graft angle and the distance. We also did not include the coronal obliquity in our study. Objective scoring or clinical outcome was not considered in the present study. The comparison of the operated group was not made with the contralateral limb of the same patient but was made with normal MRI of other people. We believe that though this comparison may not be the exact orientation for each patient but it still gives us the normal and comparative values for the population in general.

Conclusion

The postero-lateral position of the interference screw in the tibial tunnel for fixation of graft during ACL reconstruction increases the graft obliquity in sagittal plane and decreases its distance from the anterior tibial margin. This orientation resembles the normal ACL more closely than when only the anatomic positions of the tunnels are considered. A study with larger sample size and including coronal obliquity as well as clinical outcome may be required for further evaluation.

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Ethical approval

Human Research Ethics Committee of Thammasat University approved the study. Study Number is MTU-EC-OT-1-182/60.

Informed consent

Not Applicable.

Declaration of competing interest

The authors have no conflicts of interest relevant to this article.

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None.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.asmart.2020.06.003.

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