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Femoral Tunnel Three Approach Comparison for Double Bundle Anterior Cruciate Ligament Reconstruction

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Authors' contributions

This work was carried out in collaboration among all authors. Author CD designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Author AV managed the analyses of the study. Author GN managed the literature searches. The work was carried out under the guidance of author AK. All authors read and approved the final manuscript.

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ABSTRACT

Background: There is a lot of controversy surrounding the technique of femoral tunnel placement during reconstruction of anterior cruciate ligament. By our study we attempt to clarify the controversy by using three different techniques for femoral tunnel position with the same concept of tunnel creation and supported measurement data.
Methods: The creation of the femoral tunnel placement of double bundle ACL reconstruction was carried out using the behind remnant approach. The Transtibial approach was carried out for all primary Anterior Cruciate Ligament injury cases till December 2017. After that, from January 2018 to September 2018 we used the Trans-portal approach followed by which the Outside In approach was used from October 2018 to March 2019. We compared the tunnel position with a 3D reconstructed computer tomography image. We also analyzed through our study the length of each femoral tunnel and the distance between septum of every anteromedial and posterolateral tunnel.
Results: The aperture of the anteromedial bundle tunnel position in Transtibial method was higher and shallow as compared to that Trans-portal method. Also, the tunnel length in Trans-portal was shorter as compared to the Transtibial method and the Outside In approach.
Conclusion: There is a risk of antero-medial aperture position in Transtibial approach being high

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and shallow, whereas Trans-portal approach runs the risk of short tunnel length. Hence, we could conclude that it is important to apply any of the methods flexibly to each case as there is no data supporting a single best approach.

Keywords: Femoral tunnel; transtibial; transportal; outside in; anterior cruciate ligament reconstruction.

1. INTRODUCTION

Anatomic double bundle anterior cruciate ligament reconstruction [1], has advantages and is superior in terms of stability [2-6], as compared to a single bundle anterior cruciate ligament reconstruction [7-10]. However there have been reports of a high rate of failure of reconstructed anterior cruciate ligament. The cause for this failure has been due to multiple factors some of which include malalignment of limb, preoperative laxity, structure of graft and rehabilitation protocol. However, 25-85% of the failure were as a result of the technical errors during surgery, the most common being error in the placement of the tunnel position [11-13]. There is a lot of controversy surrounding the tunnel aperture of the anteromedial and posterolateral bundles and their anatomical placement. The decision of the approach of femoral tunnel placement and its proximity to the anatomical variant changes from one surgeon to another depending on the skill of the surgeon and familiarity with the approach. Basically, there are 3 major approaches for placement of femoral tunnel during anterior cruciate ligament reconstruction. Transtibial approach, Trans-portal approach and Outside In approach.

There have been various studies that have compared the femoral tunnel placement using any 2 out of the 3 above mentioned approach. However, none have showed a significant difference between Trans-portal and Outside In approach. We in our study would like to demonstrate a comparison of the merits and demerits of the three approaches of femoral tunnel placement for anatomic double bundle anterior cruciate ligament reconstruction.

2. MATERIALS AND METHODS

2.1 Patients

Ours was a case-controlled study conducted for patients who came with primary anterior cruciate ligament injuries who underwent a double bundle anterior cruciate ligament reconstruction between January 2017 and March 2019. We created the femoral tunnel during double bundle anterior cruciate ligament reconstruction as follows:

1. Transtibial approach from January 2017 to December 2017.
2. Trans-portal approach from January 2018 to September 2018.
3. Outside In approach from October 2018 to March 2019.

2.2 Exclusion Criteria

1. Multiple ligament reconstruction surgery.
2. Patients unwilling to take post-operative CT within 3 weeks after surgery.

There were 40 primary double bundle ACL reconstruction cases for Transtibial approach, 26 cases for Trans-portal and 25 cases for Outside In during each study period. So the most recent 20 patients in all the three groups were selected. There was no significant difference in patient background among all the groups (Table 1).

2.3 Surgical Procedure of the 3 Approaches

The Transtibial approach was performed as reported by Yasuda et al. [6], following the creation of the Tibial tunnel in a standardized manner. The femoral tunnel was created in the Transtibial approach through the tibial tunnel with the wire in knee flexion, proceeding the wire to the femoral lateral wall with a step by step addition of knee flexion. The angle of the final knee flexion was around 120 degrees for the anteromedial tunnel and 110 degrees for the posterolateral tunnel although it did vary with each case. This was followed by drilling with an endo button drill and we proceeded with dilatation of the tunnel to 25 mm length. This followed fixation of the femoral end gutter with endo button.

In the Trans-portal approach, the femoral tunnel was created first. This was achieved through the far anteromedial portal whose location was 10 mm distal and 20 mm medial from the anteromedial portal. The procedure of creating the tunnel was same as that of Transtibial

method. This was followed by fixation of the femoral end of the graft with endo button.

The procedure for the Outside In approach was done by using a targeting guide. This was used form the anterolateral portal and was set directly at an appropriate position on lateral wall in 90 degrees flexion of the knee. The pin was inserted and a 4 mm cannulated drill hole was penetrated along the pin followed by creation of a 15 mm socket.

2.4 Femoral Tunnel Position Assessment

The measurement of the femoral tunnel was carried out for all the three approaches and was compared in 3D computer tomography [14]. 3D computer tomography was taken three weeks after the surgical procedure to assess the femoral tunnel position. We used a sagittal view with neutral rotation of the lateral femoral condyle [15] and the center of femoral tunnels of anteromedial bundle and posterolateral bundle were assessed according to the method of the quadrant formula established by Burrard et al [14]. The Blumensaat line was used as an indicator to measure the total sagittal diameter of the lateral femoral condyle along with the use of maximum intercondylar notch height. The distance from center of the anteromedial bundle and posterolateral bundle to the most dorsal subchondral contour of the lateral femoral condyle and the distance from the center of the anteromedial and posterolateral bundle to the Blumensaat's line was expressed in terms of percentage. This measurement obtained was performed by two observers, who were blinded to the intraoperative data using Image J software [16]. An intra class correlation coefficient of 0.992 was obtained by inter observer reliability in the aperture position measurement.

2.5 Measurements of Tunnel Length and Septum Distance

We measured and recorded the length of the anteromedial and posterolateral tunnel. An intra-articular depth gauze was used for Transtibial and Trans-portal tunnel measurement. The length of the tunnel for the Outside In approach was measured utilizing retrograde depth gauze. 3D Computer Tomography was used post operatively to measure the septum distance. It was performed by two observers, using the Image J software [16].

2.6 Appearance of Femoral Fixation Device in 3dct

The assessment and comparison of the frequency of appearance of the fixation devices of the femoral tunnel was done using the sagittal 3D Computer Tomography view of the lateral femoral condyle in neutral rotation.

2.7 Statistical Analysis

The analysis of the statistics of our study was done using the ANOVA software with regards to background of the patient, the tunnel position, the length and septum distance. The significant value was set at P value <0.05. SPSS software was used.

3. RESULTS

3.1 Femoral Tunnel Aperture Position

We calculated the average of the centre of the femoral tunnel aperture in all the three approaches and our findings are demonstrated in Table 2.

The position of the Anteromedial tunnel created by the Transtibial group was statistically higher and shallower than the Trans-portal and Outside In groups. The position of the Posterolateral tunnel created by the Trans-portal group was statistically lower than the Transtibial and Outside In groups. All tunnels were created relatively deeper position in comparison with the average tunnel positions previously reported [17-19] (Fig. 1).

3.2 Femoral Tunnel Length and Septum Distance

The femoral tunnel length was compared and the findings obtained were as per Table 3. The Septum distance measurements are given in Table 4.

3.3 Femoral Fixation Device

Our finding was that 11 out of 20 cases in the Transtibial group showed the fixation device to be on the posterior articular surface of the lateral femoral condyle (Fig. 2). Such findings were not observed in the Trans-portal and Outside in approach groups.

Table 1. Patient background

	Transtibial group	Trans-portal group	Outside-In group	P-value
Age	26.2+/-6.2	26.4+/-5.2	25.3+/-3.1	0.947
Gender(Male/Female)	12/8	12/8	15/5	0.517
Height	165.7+/-3.4	164.4+/-4.1	167.4+/-4.5	0.497
Weight	60.5+/-5.1	64.2+/-7.7	67.4+/-6.5	0.242

Table 2. Femoral tunnel aperture position comparison in the three approaches

	Transtibial approach	Trans-portal approach	Outside In approach	Anatomic centre
Anteromedial Height (%)	26.2 +/- 4.4	34.2 +/- 4.6	31.6 +/- 5.9	17.4
Posterolateral Height (%)	49.5 +/- 5.5	55.4 +/-3.6	49.7 +/- 4.4	42.6
Anteromedial Depth (%)	26.1 +/- 2.8	21.5 +/- 2.1	22.6 +/- 2.7	25.3
Posterolateral Depth (%)	35.5 +/- 3.3	35.1 +/- 3.9	37.5 +/- 3.4	33.3

Table 3. Femoral tunnel length

Tunnel length	Transtibial group	Trans-portal group	Outside In group	P-value
Anteromedial tunnel (mm)	40 ± 4	30 ±4	39 ± 5	<0.01
Posterolateral tunnel (mm)	37 ± 4	33 ±4	41 ± 5	<0.01

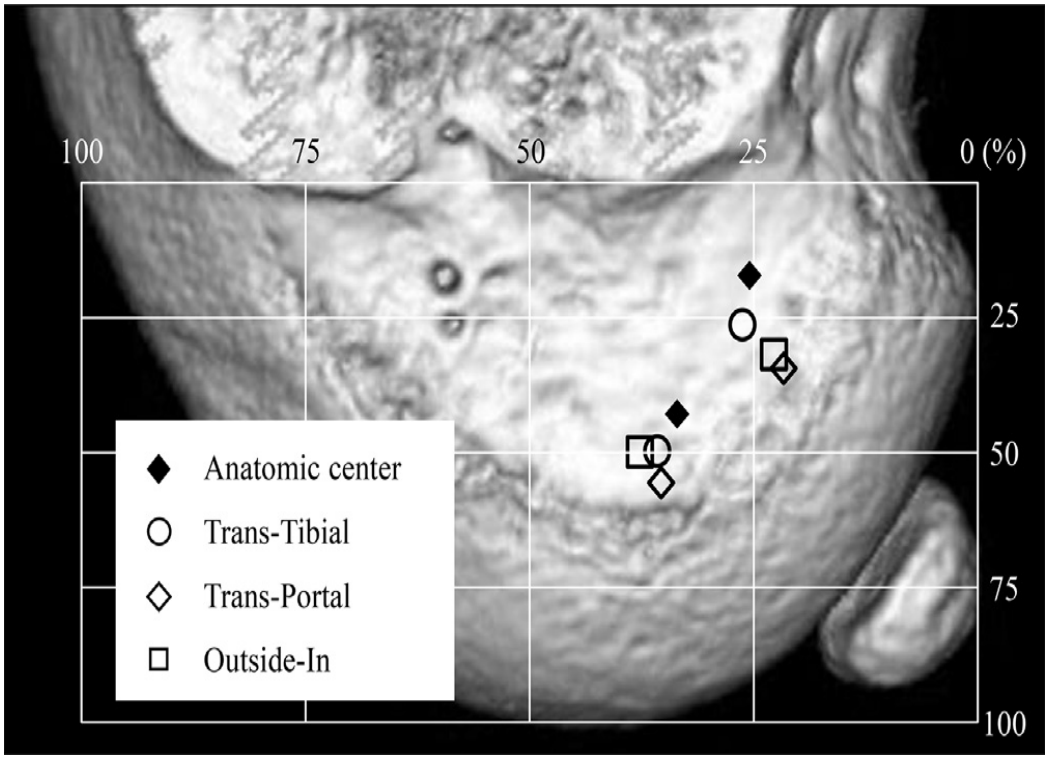

Fig. 1. Femoral tunnel position as plotted by the quadrant method

Table 4. Septum distance

Septum between Anteromedial and Posterolateral	Transtibial group	Trans-portal group	Outside In group	P-value
Septum Distance (mm)	1.4 ± 0.4	1.6 ± 1.4	2.1 ± 1.3	0.459

Fig. 2. Postoperative 3D-CT sagittal image of Trans-Portal approach with the femoral fixation device (arrow)

4. DISCUSSION

Our study demonstrated various features of Transtibial, Trans-portal and Outside In approaches on femoral tunnel creation during double bundle ACL reconstruction. The centre of the aperture of the femoral tunnel was higher using the Transtibial approach. The length of the femoral tunnel was shorter in the approach by the Trans-portal method than in others. There was no significant difference among the three approaches in our study for comparison between the anteromedial and posterolateral tunnel apertures for septum distance. This is a unique study which compared the three approaches of femoral tunnel placement in the same institute, there are very less studies of a similar kind in literature.

The results of similar kind of previous studies which compared the apertures of the femoral tunnel in a similar concept or cadaveric manner revealed superiority of Trans-portal and Outside In over Transtibial [20-22]. In comparison to our study, while the anteromedial aperture was higher than others, it was still lower than the anatomic centre previously reported [23] and it was within anatomical position following our femoral tunnel position concept. There is controversy whether the “anatomic” femoral tunnel aperture position should be created reproducing the native ACL in consideration of graft function in the ACLR. In previous anatomic studies, there is controversy by the claims that the normal femoral attachment site is at the direct insertion [6], at the indirect insertion [24], and at the border of these [25]. In consideration of the graft translation functional area in the femoral tunnel, we targeted the centre of femoral tunnel aperture at the posterior border of the direct insertion without any removal of the remnant tissue. In this method, the remnant tissue at femoral attachment prevents the risk of high femoral tunnel aperture position. This concept of the “behind-remnant approach” is useful not only as a remnant preserving ACLR fit to the individual anatomic variation but also for avoiding non-anatomical tunnel creation in TT approach.

Tomihara et al. compared the septum distance between TP and OI by postoperative CT measurements, and revealed there was no significant difference [26]. This report supports our current study. However, because each report varies in its concept of the femoral tunnel creation, the simple comparison is not appropriate. We discovered the following features of these approaches: the TT approach trended in a higher and shallower tunnel aperture position especially in the Anteromedial femoral tunnel, but it was within anatomical position in our femoral tunnel creation concept. The femoral tunnel aperture positions created by Outside In approach were intermediate among these three approaches. On the other hand, although the concept of the TT approach is simple and superior to graft passing, there exists the technical difficulty that the femoral tunnel depends on tibial tunnel angle and diameter, and on a shallow angle approach for the lateral wall. It is relatively easy for the Trans-portal approach to target the appropriate femoral tunnel aperture position, but the tunnel length trends short and requires deep flexion of the knee to avoid the posterior blow out of the lateral femoral condyle. The Outside In approach is also a relatively easy approach, but the low accuracy of the femoral targeting device requires the skill of mature surgeons. Moreover, the Trans-portal and Outside In approaches require the relay-technique for graft passing.

5. CONCLUSION

In conclusion, the Anteromedial tunnel aperture position of Transtibial approach runs the risk of a high and shallow position. Trans-portal approach runs the risk of insufficiently short tunnel length. It is important to apply each method flexibly to each case because no single best approach was found.

CONSENT

An informed written consent was taken from all the patients and they were explained about the study.

ETHICAL APPROVAL

As per international standard or university standard written ethical approval has been collected and preserved by the author(s).

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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