Anteromedial portal technique versus trans-tibial technique for anterior cruciate ligament single-bundle reconstruction: in-vivo anatomical study

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Purpose

The purpose of this study was to determine, *in vivo*, – whether drilling the femoral tunnel through the anteromedial portal (AMP), as opposed to drilling the tunnel trans-tibially (TT), will increase the reliability to reach the center of the femoral insertion in single-bundle anterior cruciate ligament (ACL) reconstruction.

Patients and methods

Fifty-four consecutive patients undergoing primary ACL reconstruction with a four-strand hamstring tendon autograft were enrolled in a prospective case series. Cases were divided according to the landmarks used to identify the starting point of femoral tunnel into two groups: group I included patients in whom the ACL stump was used (24 patients), whereas group II included patients in whom the ACL stump was not found and the lateral intercondylar ridge was used (30 patients).

Results

Using the AMP resulted in a statistically significant higher incidence of reaching the anatomical femoral insertion site of the ACL compared with the TT approach (100 vs. 16.33%, $P<0.05$). Comparison of the two groups showed that 3/24 patients in group I had an off-center position compared with 6/30 in group II, whereas 21/24 patients in group I had an outside position compared with 24/30 patients in group II, with no statistically significant difference between the two groups [Fisher's exact test, $P=0.72$; Relative Risk (RR)=1.4 (95% confidence interval=0.53–3.17)].

Conclusion

AMP technique allows more accurate positioning of the starting point of femoral tunnel when compared with the TT technique in anatomical single-bundle ACL reconstruction.

Level of evidence

Level IV (case series).

Keywords:
anterior cruciate ligament, single-bundle reconstruction?, trans-tibial technique

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Introduction

Reconstruction of the anterior cruciate ligament (ACL) is a well-established procedure worldwide [1,2]. The ACL is formed of two functional bundles named for their tibial insertion sites: the anteromedial (AM) and the posterolateral (PL) bundles. One of the greatest challenges of arthroscopic ACL reconstruction is to locate the femoral insertion site in a reproducible manner. The lateral intercondylar ridge (resident's ridge) marks the anterior border of the ACL femoral insertion. It runs from superior–anterior to inferior–posterior on the lateral notch wall at an ∼30–35° angle with respect to the long axis of the femoral shaft and about 10 mm anterior to the posterior margin of the lateral femoral condyle. The femoral attachment of AM bundle originates from the proximal part of the femoral footprint, whereas the PL bundle originates from the distal part. The lateral bifurcate ridge runs perpendicular to the lateral intercondylar ridge and is located between the AM and PL femoral insertion sites [3–8].

The concept of anatomic ACL reconstruction aims to restore normal knee kinematics, improve pivot shift resistance, and increase rotational control. Correct placement of the femoral tunnel is a prerequisite to successful ACL reconstruction. Traditional single-bundle ACL reconstruction may effectively stabilize anterior tibial translation. Meanwhile, placing the femoral bone tunnel toward the lateral notch wall more effectively improves knee kinematics and rotational stability when compared with tunnel placement close to the roof of the intercondylar notch as in the trans-tibial (TT) technique [9–14].

When using the TT technique, the location of the femoral tunnel is restricted by the angulation of the tibial tunnel in both the frontal and sagittal planes, resulting in nonanatomic placement of the femoral tunnel. Otherwise, the tibial tunnel will necessarily be very short and start close to the tibial articular surface. As a result of the desire to perform independent drilling of the femoral tunnel, there has been an interest in the anteromedial portal (AMP) technique. However, the technique has a learning curve, which could be challenging, with higher incidence of complications including the possibility of damaging the articular cartilage of the medial femoral condyle, proximity of the exit point of the guide pin to the common peroneal nerve, and shorter femoral tunnel length compared with the TT technique [15–20].

The aim of this anatomical in-vivo study is to intraoperatively evaluate the accuracy of the starting point of the femoral tunnel in relation to the anatomical landmarks of the ACL femoral footprint in single-bundle ACL reconstruction when drilling the femoral tunnel through the AMP versus the TT method.

Patients and methods

Fifty-four consecutive patients undergoing primary ACL reconstruction with a four-strand hamstring tendon autograft were enrolled in a prospective case series study. The background information (Table 1) included age at the time of surgery, sex, side involved, and duration of injury. All patients presented with isolated ACL injury diagnosed by clinical examination and by MRI.

Exclusion criteria were ACL revision surgery, moderate to severe osteoarthritic changes in preoperative radiography, multiligamentous injury, and cases in which neither the ACL stump nor the lateral intercondylar ridge was identified. After obtaining local ethics committee approval, preoperative education regarding the expected outcome of surgery was done and an informed consent was signed by all patients.

Operative technique

Surgery was performed in the supine position with the knee freely mobile. Pneumatic tourniquet was maintained on the thigh throughout the procedure. After harvesting the hamstring graft, an anterolateral portal was established as the primary viewing portal. It was placed just below the inferior pole of the patella and directly adjacent to the patellar tendon. An AMP was then established as a working portal and a secondary viewing portal under direct intra-articular visualization by the use of a long needle to avoid damage to the anterior horn of the medial meniscus. The needle was inserted into the joint right above the medial meniscus as medial as possible to provide access to the lateral wall of the intercondylar notch and the femoral footprint as perpendicular as possible. The needle was easily placed into the center of the ACL femoral footprint, and sufficiently distant from the medial femoral condyle to avoid its iatrogenic injury while reaming. A complete diagnostic arthroscopy was performed to confirm the ACL injury and to address and manage any intra-articular pathology.

The femoral tunnel was drilled through the AMP after clearing the notch without performing notchplasty. The guide pin was drilled using a free-hand technique with the knee flexed to 110°. Standard landmarks were used to identify the correct position of the guide pin. The native footprint of the ACL, including AM and PL insertion sites, on the intercondylar notch was used if the ACL stump was found (Fig. 1). A curved microfracture awl inserted through the AMP was used to mark the center of the femoral tunnel in the center of the ACL stump. If the stump was not found, the lateral intercondylar ridge and the bifurcate ridge were used as bony landmarks (Fig. 2). The center of the femoral tunnel was identified at a point just deep to the bifurcate ridge in the middle of the area between the lateral intercondylar ridge and the posterior articular cartilage border. The position of the femoral tunnel was then rechecked by using the AMP as a viewing portal. After drilling the femoral tunnel, the presence or absence of posterior blowout was checked.

Table 1 The baseline characteristics of patients included in the current study

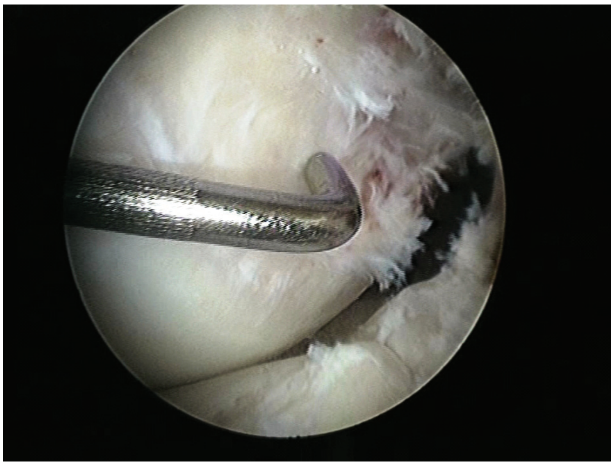
	Total			Group I (24 patients)			Group II (30 patients)			*P*-value
	Mean	SD	Range	Mean	SD	Range	Mean	SD	Range	
Age (years)	27	4	20–36	26.2	4.4	20–36	27.5	3.7	20–35	0.25
Duration (months)	6.5	3.3	2–18	5.5	2.9	2–12	7.2	3.5	4–18	0.07
Sex [*n* (%)]										
Male	42 (78)			17 (71)			25 (83)			0.33
Female	12 (22)			7 (29)			5 (17)			
Side	24 right (44%)30 left (56%)			10 right (42%)14 left (58%)			14 right (47%)16 left (53%)			0.79

To compare the accuracy of the different landmarks used to identify the center of the femoral tunnel, cases were divided according to the landmarks used into two groups (Table 1): group I included patients in whom the ACL stump was used (24 patients), whereas group II included patients in whom the ACL stump was not found and the lateral intercondylar ridge was used (30 patients).

The tibial tunnel was then drilled in the anatomic position at the ligament's footprint using an endoscopic C-guide inserted through the AMP adjusted to 55° in the sagittal plane. The starting point was located midway between the anterior edge of the medial collateral ligament and the tibial tuberosity. The deviation from the sagittal plane was about 20°. The exit point was in the middle of the tibial ACL footprint. The guide pin was then overdrilled to the proper diameter using a cannulated reamer.

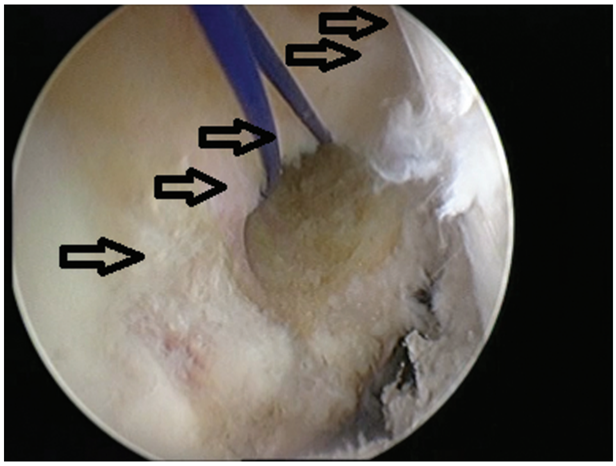
Then, the guide pin was placed through the tibial tunnel trying to enter the femoral tunnel in various degrees of knee flexion angles. The position of the pin was described as being (a) easily placed in the center of the femoral tunnel, (b) off-center within the femoral insertion site (Fig. 3), or (c) outside the femoral insertion site (Fig. 4).

Figure 1



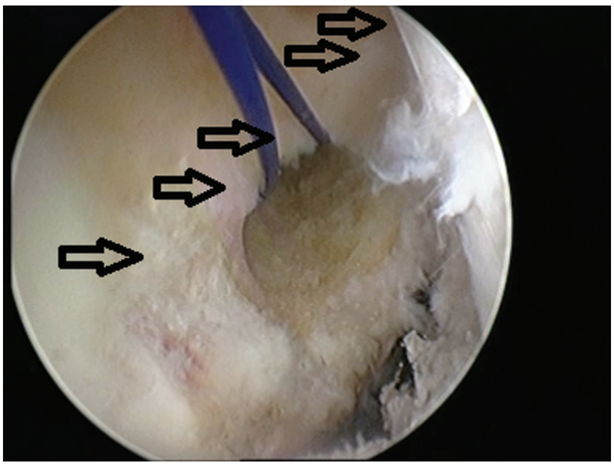
Arthroscopic view through the anteromedial portal showing the femoral insertion site of the native ruptured anterior cruciate ligament (ACL), with the arthroscopic probe placed through the standard lateral portal, onto the lateral intercondylar ridge.

Figure 2



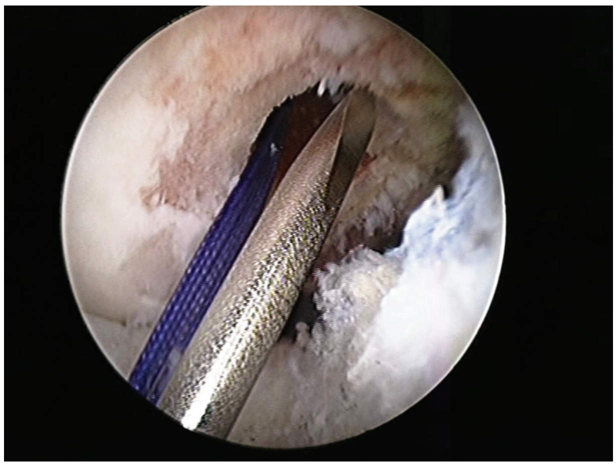
Arthroscopic view through the anteromedial portal showing relation of the femoral tunnel and the lateral intercondylar ridge (arrows).

Figure 3



Arthroscopic view through the anteromedial portal showing the femoral tunnel drilled in the center of the native anterior cruciate ligament (ACL) femoral footprint (containing the passing suture) and the pin passed through the tibial tunnel. The tip of the guide pin is off-center to the femoral tunnel.

Figure 4



Arthroscopic view through the anteromedial portal showing the femoral tunnel drilled in the center of the native anterior cruciate ligament (ACL) femoral footprint (containing the passing suture) and the pin passed through the tibial tunnel. The drill hole of the tip of the guide pin is outside the femoral insertion site of the ACL.

Statistics

PASW version 18 (IBM, Chicago, Illinois, USA) was used for statistical analysis. Descriptive analysis was conducted to explore the characteristics of the participants at baseline. The mean and the SD of age, duration to operation, and the percentages of the sex and side distribution were calculated.

Continuous variables were tested for normality. For comparing the two groups, variables were analyzed using two-tailed unpaired *t*-tests or Mann–Whitney *U*-test as appropriate. Fisher's exact test was used for categorical data, and χ^2-test was used for comparing the accuracy of the position of the guide pin in relation to the anatomical landmarks of the femoral footprint for each technique. The difference was considered statistically significant if *P*-value is less than 0.05.

Results

The average patient age at the time of operation was 27±4 years. Group I included 24 patients, whereas group II included 30 patients. No statistically significant difference was found between both groups, regarding patient demographics ($P>0.05$), as shown in Table 1.

Results of the current study are presented in Table 2. Through the tibial tunnel, the guide pin was inserted outside of (anterior to) the anatomic insertion site in 45 of 54 cases (83.33%), off-center in nine of 54 cases (16.66%), and it could not be inserted in the center of the femoral anatomic insertion site in any of the reported cases.

Comparison of the two groups showed that 3/24 patients in group I had an off-center position compared with 6/30 patients in group II, whereas 21/24 patients in group I had an outside position compared with 24/30 patients in group II, with no statistically significant difference between the two groups [Fisher's exact test, $P=0.72$; RR=1.4 (95% confidence interval=0.53–3.17)].

Using the AMP resulted in a statistically significantly higher incidence of reaching the anatomical femoral insertion site of the ACL compared with the TT approach (100 vs. 16.66%) (Fisher's exact test, $P=0.0027$; RR=infinity). Posterior cortical wall blowout or peroneal nerve injury was not reported in any case.

Discussion

The accuracy of the AMP technique compared with the TT technique in localizing the anatomical femoral tunnel starting point during ACL reconstruction has been proven by many cadaveric [21–24] and radiological studies [25–27]. In the current study, we assessed the accuracy of both techniques in single-bundle ACL reconstruction *in vivo*. The result of this in-vivo anatomical study proves that we cannot reliably reach the center of the femoral insertion of the ACL when using the TT approach to drill the femoral tunnel. On the contrary, it was reached through the AMP technique in all cases included in this study. A previous study reported comparable results regarding double-bundle ACL reconstruction [28]. It is technically not possible to reach the center of the femoral PL bundle insertion site through either one of the tibial tunnels. With regard to the femoral AM bundle, the AMP technique was found to be more accurate as opposed to drilling the tunnel TT.

Small variations in femoral tunnel placement can have large effects on kinematics of the moving knee [29]. To place the graft correctly, independent drilling of the tibial and femoral tunnels is required. When using a TT technique, the location of the femoral tunnel is restricted by the angulation of the tibial tunnel, resulting in a mismatched and nonanatomical placement of the femoral tunnel with a tendency for the femoral tunnel to be placed more toward the roof of the notch. It was found that the femoral tunnel can be positioned correctly in the center of the femoral ACL footprint by means of the TT technique if the tibial tunnel is angled at 60–65° to the tibial articular surface in the coronal plane starting from a more medial starting point [20]. However, this low tibial angle increases the risk of tibial plateau articular injury, medial collateral ligament injury, and having a short tibial tunnel with an elliptical aperture. Furthermore, the eccentric positioning of the guide wire in the tibial tunnel may result in iatrogenic re-reaming

Table 2 Results of both groups included in the current study

Guide-wire position	Total (54 patients) [*n* (%)]	Group I (24 patients) [*n* (%)]	Group II (30 patients) [*n* (%)]	*P*-value
Outside	45 (83.33)	21 (87.5)	24 (80)	0.72
Off-center	9 (16.66)	3 (12.5)	6 (20)	
Central	0	0	0	

of the tibial tunnel and tibial aperture expansion [18,21,24,26,27].

The AMP technique allows more angulation of the femoral tunnel toward the lateral notch wall in the coronal plane, which improves transverse plane rotatory stability in comparison with a more vertical tunnel. On the other hand, the TT technique focuses primarily on reproducing the AM bundle in single-bundle technique. Despite achieving satisfactory results for anterior–posterior laxity, this method failed to restore the native kinematics of the knee, especially rotatory control. In addition, the AMP technique allows parallel placement of interference screw fixation through the same portal used for tunnel creation. Another advantage of anatomic tunnel placement is that the graft is exposed to normal biomechanical stimuli, and therefore a more favorable biological environment for healing and a lesser degree of bony tunnel expansion are achieved. On the other hand, nonanatomic tunnel placement results in limited range of motion, higher than physiologic graft tension, and ultimately graft failure [9,29–32].

However, the AMP technique is more technically demanding and less suitable for obese patients. Complications and challenges include short tunnel, distal and/or posterior exit of the guide pin from the lateral thigh (approaching the peroneal nerve), iatrogenic damage to the cartilage of the medial femoral condyle, bending of a rigid guide wire in the hyperflexed position, and difficulty of visualization, orientation, reaming, graft passage, and fixation in the hyperflexion position. In addition, several guide instruments are designed for the TT technique and cannot be accurately applied through the AMP. Increased angulation between the bone tunnel and the intra-articular portion of the graft may theoretically lead to higher stresses that may cause bone tunnel enlargement [33–37]. However, posterior cortical wall blowout or peroneal nerve injury was not reported in any case in the current study.

In the current study, fixed anatomical landmarks besides the ACL stump were used to define the ideal position of the femoral tunnel. The lateral intercondylar ridge represents a fixed and reliable landmark for the femoral footprint. It has been shown to be present and visible in more than 85% of chronic ACL-deficient knees [8,38]. The anterior fibers of the ACL inserts immediately posterior to the most prominent edge of this ridge [39]. Comparable results were recorded when using either the ACL stump or the lateral intercondylar ridge as a landmark for the anatomical femoral footprint of the ACL (Table 2). Although the 'clock face' reference has been previously widely accepted in literature, it was not used in the current study being largely subjective. It does not provide orientation of the clock face to known anatomy, it does not appreciate the three-dimensional structure and the asymmetric anatomy of the notch, and it is dependent on the knee flexion angle. It commonly refers to a knee flexion angle of 90° [40].

In the current study, the guide pin was drilled using a free-hand technique with the knee flexed to 110°. The results of a cadaveric study [41] showed that 110° is the optimum knee flexion angle for insertion of the guide pin, whereas 130° of knee flexion is responsible for high tunnel acuity. Flexion of the knee to 90° only leads to critically short tunnel (<25 mm) with potential risk of posterior wall blowout and damage to the common peroneal nerve [10,11].

The current study has few limitations. Identification of the ACL stump to define the ideal position of the femoral tunnel was not possible in 30/54 cases. However, fixed anatomical landmarks were used to improve the accuracy of localization of the center of the ACL footprint. Fixed angle to drill the tibial tunnel was utilized to have the best tibial tunnel inclination regardless of its relation to the femoral insertion site. Free-hand technique was used for drilling the guide pin, as it is often difficult to position a conventional offset guide with the knee in hyperflexion. However, experience with the AMP technique is encouraging. It was found to be more accurate compared with the TT technique in anatomical single-bundle ACL reconstruction. Further studies are recommended to assess the effect of using specially designed offset guides, flexible guide pins, and flexible reamers on the accuracy of the technique.

Conclusion

AMP technique allows more accurate positioning of the starting point of femoral tunnel when compared with the TT technique in anatomical single-bundle ACL reconstruction.

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Nil.

Conflicts of interest

There are no conflicts of interest.

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