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원 저

전방십자인대 재건술시 대퇴골 터널에 있어 전내측 삽입구의 유용성

부산 동의의료원 정형외과

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Usefulness of Anteromedial Portal for Femoral Tunneling in Anterior Cruciate Ligament Reconstruction

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Purpose: Recent development and advances in the arthroscopic surgical techniques for anterior cruciate ligament (ACL) reconstruction have led to the ideal location for more oblique anatomic point of the femur from 10 to 10:30 o'clock (in the right knee) and from 2 to 1:30 o'clock (in the left knee) in the frontal plane. This study was performed to compare the operative methods and the radiologic results of the femoral tunnels made through the tibial tunnel (trans-tibial approach) and the anteromedial portal.

Materials and Methods: From January 2003 to May 2004, one hundred reconstructions of ACL were performed. Group I (the femoral tunnel made through the tibial tunnel) consisted of 50 cases and group I (the femoral tunnel made through the anteromedial portal) consisted of 50 cases. The operative methods and the radiographic results of the femoral tunnels were compared.

Results: Femoral tunnel was made more easily at more oblique anatomic point in group II than in group I. In group II, better visual field was achieved at the angle of 100? flexion of the knee joint, the risks of the posterior cortical breakage and the tunnel-graft mismatching were reduced more, and the divergence of femoral interference screw from the radiograph decreased more than in group I ($p<0.05$). The angle between the femoral tunnel and the longitudinal axis of ACL increased in group II.

Conclusion: Anteromedial portal technique was useful for femoral tunneling toward 10 to 10:30 o'clock (in the right knee) and 2 to 1:30 o'clock (in the left knee) in ACL reconstruction. Level of Evidence : Level III, case-control study

KEY WORDS: Femoral tunnel, Trans-tibial portal, Anteromedial portal, ACL reconstruction

Introduction

For the successful reconstruction of anterior cruciate ligament (ACL), the selection and harvesting of the graft material, isometry, tensioning of the ligament, method of fixation, and, especially, the locations of the femoral and tibial tunnel are important[1-6].

There are several methods in femoral tunnel reconstruction; double-incision technique, single-incision trans-tibial technique, and single-incision anteromedial portal technique. Giron et al[7]. described that the experience and the preference of the operator, clinical results, consent of patient, and cosmetic aspect must be considered in the selection of the method in femoral tunnel reconstruction. According to previous literature isometric point of the femoral tunnel is near the site of the attachment of the anteromedial fiber of ACL[8,9].

However, recent studies suggest that reconstructing the femoral tunnel at the oblique anatomic origin

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of the native ACL more closely restored anatomic rotational stability to the knee than did the standard tunnel reconstruction[10,11].

This study is to compare the operative methods and the postoperative radiographs of the trans-tibial and anteromedial portal approach in femoral tunneling of ACL reconstruction using patella tendon complex, when the isometric point is made at 10 to 10:30 o'clock (in the right knee) and 2 to 1:30 o'clock (in the left knee).

Materials and methods

1. Material

A retrospective review was performed of the records and radiographs of 100 consecutive ACL reconstructions that were performed using bone-patellar tendon-bone allograft or patella tendon autograft between January 2003 and May 2004. We compared 50 cases in which the trans-tibial technique was used group I with 50 cases in which the anteromedial portal technique was used group II. The detailed demographic data and the accompanying injuries are shown in Table 1. We included these with meniscal injury but excluded these with combined posterior cruciate ligamat (PCL) injury or collateral ligament injury. With regard to the isometric point of the femoral tunnel, we set a goal of 10 to 10:30 o'clock (in the right knee) and 2 to 1:30 o'clock (in the left knee). We compared the operative methods and postoperative radiographs between group I and II.

2. Method

The operative methods in group I went through as usual, notchplasty, tibial tunneling, femoral tunneling, insertion of ligament, and fixation of the interference screw were performed. Maintaining 70~80° flexion of knee joint, the guide pin was inserted to the femoral tunnel through the tibial tunnel which

Table 1. Patient data and accompanying injuries

	group I	group II
Age at surgery (years)	28 (18~55)	26 (19~51)
Gender (M : F)	46 : 4	45 : 5
Accompanying injuries	32 (64%)	33 (66%)
Medial meniscus tear	19 (38%)	21 (42%)
Lateral meniscus tear	6 (12%)	7 (14%)
Medial & lateral meniscus tear	7 (14%)	5 (10%)

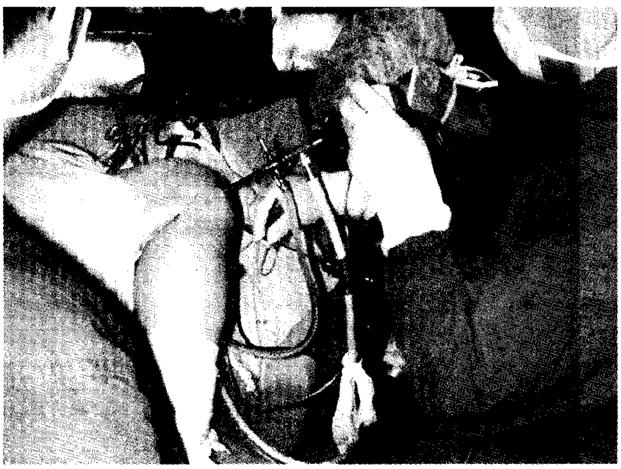

Fig. 1. Femoral tunnel is made through anteromedial portal under 100° flexion and valgus of the knee joint and external rotation of the tibia.

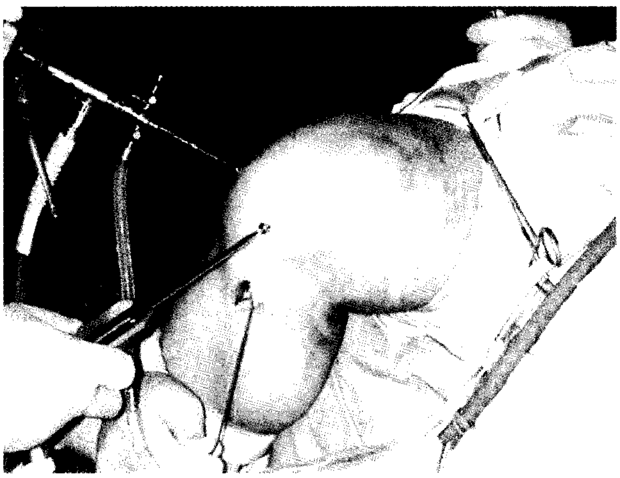

Fig. 2. Femoral interference screw is inserted through anteromedial portal under 100° flexion and valgus of the knee joint and external rotation of the tibia.

was already made, and to approach to 10 or 2 o'clock position of the femoral tunnel, valgus of the knee joint and internal rotation of the tibia were accompanied. In group II, after notchplasty and tibial tunneling, femoral tunnel was made through the anteromedial portal, while maintaining 100° flexion and varus of the knee joint, and external rotation of the tibia (Fig. 1). After the target point was marked on the femur maintaining the knee joint flexed 70~80°, the guide pin for the femoral tunnel was inserted keeping the knee joint flexed 100°. After femoral tunneling, we chamfered on the entrance of the tunnel anteroinferiorly. And then we passed the thread along the guide pin to the femoral tunnel, and passed it out through the tibial tunnel. Using thread, we passed the graft and inserted the interference screw maintaining 100° flexion and varus of the knee joint and external rotation of the tibia (Fig. 2).

3. Radiologic result

On the anteroposterior radiographs, we measured the angle between the center of the intercondylar notch (the intersecting point of the femoral anatomical axis and the femoral joint line) and the entrance of the femoral tunnel (Fig. 3), the angle between the femoral tunnel and the longitudinal axis of ACL (Fig. 4), and the angle between the femoral tunnel and the tibial tunnel (Fig. 5). On the lateral radiographs, we measured the angle between the femoral tunnel and the Blumensaat's line (Fig. 6). Statistical analysis was performed using student T-test and Fisher's exact test.

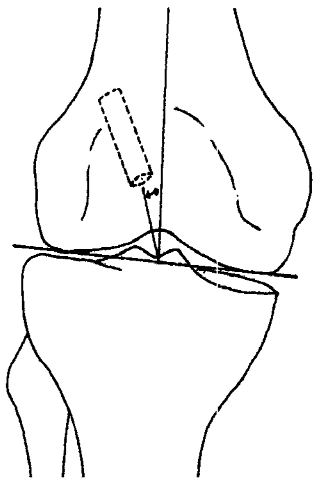

Fig. 3. Direction from the center of the intercondylar notch (intersecting point of the femoral anatomic axis and the femoral joint line) to the entry point of the femoral tunnel (FT location)

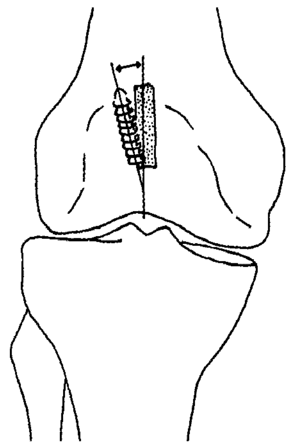

Fig. 4. Angle of the femoral divergence between the interference screw and the bone graft.

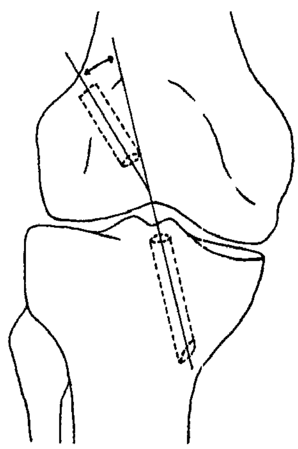

Fig. 5. Angle between the femoral tunnel and the tibia tunnel in anteroposterior view (FT-TT angle).

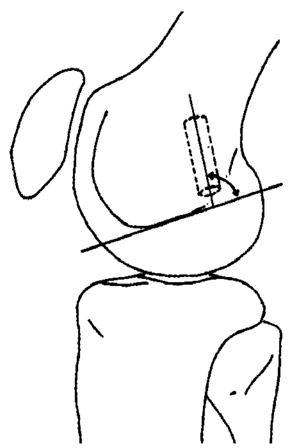

Fig. 6. Angle between the femoral tunnel and the Blumensaat's line in lateral view (B-FT angle).

Results

1. Comparison of the operative methods

In the trans-tibial approach (group I), it was not easy to approach to 10 to 10:30 o'clock (in the right knee) and 2 to 1:30 o'clock (in the left knee) positions because the guide pin passed through the narrower and longer pathway (tibial tunnel itself). But in the anteromedial approach (group II), it was possible to approximate to 9 to 11 o'clock (in the right knee) and 3 to 1 o'clock (in the left knee) regardless of the tibial tunnel (Fig. 7). In group II, because the femoral tunnel was made with the knee joint flexed 100°, the arthroscope could be proceeded deeper than in group I, and better visual field to the intercondylar notch was achieved, which provided easiness for the identification of the more oblique anatomic point of the femoral tunnel and for the insertion of the guide pin. In group II, the insertion of the interference screw was easier due to the wider visual field than in group I, in which it was done with the knee joint flexed 120° or more.

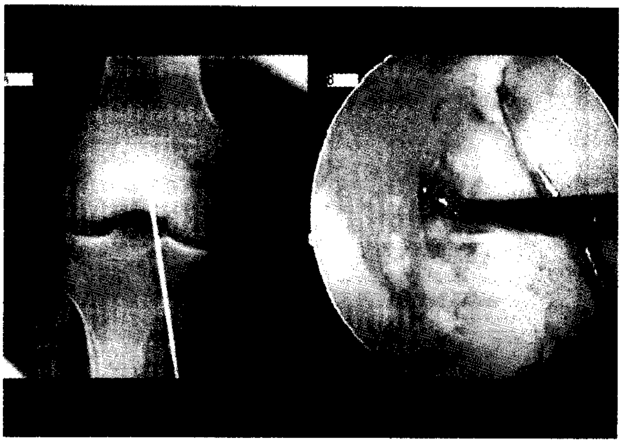

Fig. 7. Direction of the guide pin through the tibial tunnel shows toward 11 to 11:30 o'clock (A and B) and probe through anteromedial portal shows toward 10 to 10:30 o'clock (B) in right.

2. Radiologic results

On the anteroposterior radiographs, the mean angles between the line from the intercondylar notch to the entrance of the femoral tunnel and the femoral anatomical axis were 37.2±10.5° in group I and 48.2 ±8.2 ° in group II, respectively ($p<0.05$). This suggest that it was easier to approximate to the ideal point in group II than in group I (Table 2). On the anteroposterior radiographs, the mean angles between the femoral tunnel and the longitudinal axis of ACL were 6.0±6.2° (0~29°) in group I and 1.8±2.6° (0~14°) in group II, respectively ($p<0.05$). On the lateral radiographs, they were 6.5±6.4° (0~31°) in group I and 2.7±3.1° (0~16°) in group II, respectively ($p<0.05$). There were stastically significant decreases in three parameters in group II (Table 2, 3). On the anteroposterior radiographs, the mean angles of the femoral tunnel and the tibial tunnel were 8.6±6.4° in group I and 17.5±5.6° in group II, respectively ($p<0.05$). On the lateral radiographs, the mean angles of the femoral tunnel and the Blumensaat's line were 76.3±5.8° in group I and 87.1±9.5° in group II, respectively ($p<0.05$). The femoral tunnel was almost perpendicular to the Blumensaat's line in group II (Table 2) (Fig. 8).

Table 2. Angles in the trans-tibial and the anteromedial portal techniques (mean ± SD)

	FT location‡	Interference screw divergence: Anteroposterior View	Interference screw divergence: Lateral View	FT-TT angle§	B-FT angle
TT*	37.2 ± 10.5 °	6.0 ± 6.2 °	6.5 ± 6.4 °	8.6 ± 6.4 °	76.3 ± 5.8 °
AM†	48.3 ± 8.2 °	1.8 ± 2.6 °	2.7 ± 3.1 °	17.5 ± 5.6 °	87.1 ± 9.5 °
P-value	<0.05	<0.05	<0.05	<0.05	<0.05

* : Trans-tibial technique
† : Anteromedial portal technique
‡ : Femoral tunnel location
§ : Angle between the femoral tunnel and the tibial tunnel
: Angle between the Blumensaat's line and the femoral tunnel

3. Functional results

Lachman test turned out to be mildly positive (+) in 12 cases and moderately positive (++) in 3 cases in group I, and mildly positive (+) in 9 cases and moderately positive (++) in 3 cases in group II, with no statistical significance between the two groups. Both groups had 3 cases of a mildly positive outcome (+) on pivot-shift test, whereas all other cases remained negative. The preoperative HSS scove had improved at the postoperative assessment. The mean HSS scove improved from 61.4 to 94.8 in group I and from 64.3 to 95.1 in group II at the last review, with no statistical significance between the two groups.

Discussion

Most authors have regarded the isometric point of the femoral tunnel as 11 o'clock (in the right knee) and 1 o'clock (in the left knee)[8,9]. But regarding the rotatory as well as the anteroposterior stability of the knee joint, more oblique orientation has been more concerned. Cain et al[12]. suggested that the isometric point of the femoral tunnel is 10 to 10:30 o' clock (in the right knee) and 2 to 1:30 o'clock (in the left knee). In a comparative study regarding 10 or 11 o'clock femoral placement, Loh et al[10]. reported that the anterior tibial translation was similar between 10 and 11 o'clock femoral tunnel placements, but there was superiority for the stability against the rotatory load in 10 o'clock femoral placement. Scopp et al[11]. reported that there were similar results in the ante-

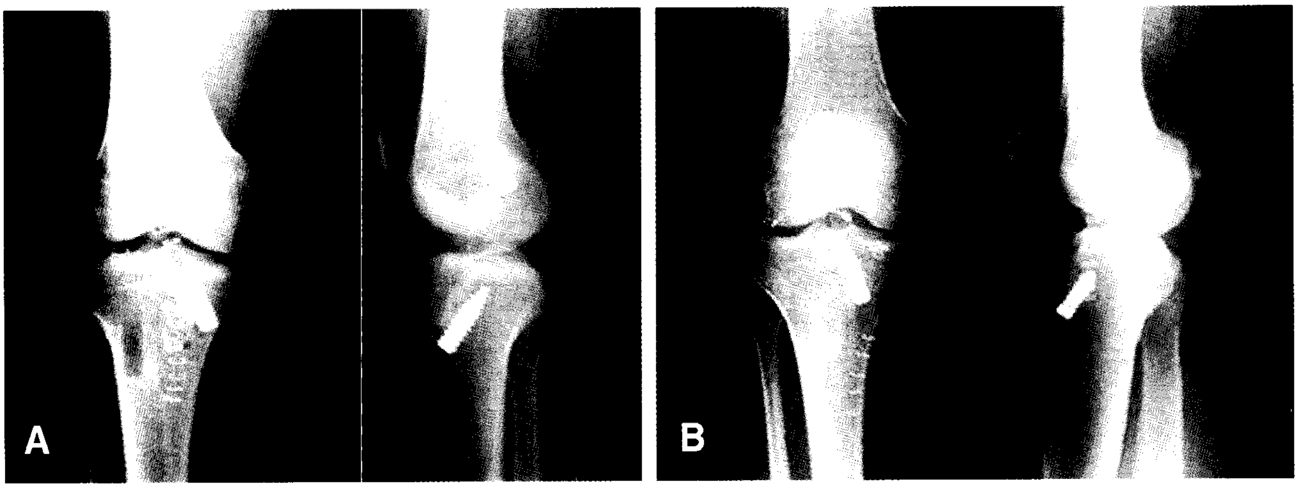

Fig. 8. In the anteromedial portal technique **(A)**, femoral tunnel can be made more closely to the isometric point, the angle beween the femoral tunnel and the tibial tunnel in the coronal plane is larger, and the angle between the femoral tunnel and the Blumenssat's line in the sagittal plane is closer to 90° than in the trans-tibial technique **(B)**.

Table 3. Distribution of interference screw divergence

Interference screw divergence (°)	Trans-tibial technique n (%)		Anteromedial portal technique n (%)	
	Anteroposterior	Lateral	Anteroposterior	Lateral
0~4	15 (30)	12 (24)	38 (76)	29 (58)
5~9	17 (34)	20 (40)	9 (18)	17 (34)
10~14	9 (18)	11 (22)	3 (6)	3 (6)
15~19	4 (8)	3 (6)	-	1 (2)
20~24	3 (6)	2 (4)	-	-
25~29	2 (4)	1 (2)	-	-
>30	-	1 (2)	-	-
Total	50 (100)	50 (100)	50 (100)	50 (100)

rior tibial translation and the external rotation of tibia between 10 and 11 o'clock femoral tunnel placements, but there was superiority for the stability against the internal rotation of tibia in 10 o'clock femoral placement. Several methods for femoral tunnel have been introduced such as double-incision technique, single-incision trans-tibial technique, and single-incision anteromedial portal technique initially introduced by O'Donell and Acerpella[13]. Aglietti[14] described that the mean angles of the femoral tunnel on the coronal plane were 37° in the double- incision technique, 68° in the trans-tibial technique, and 50° in the anteromedial portal technique. Giron et al[7]. described that the guide pin was liable to approach to 11 to 11:30 o'clock (in the right knee) in the trans-tibial technique.

We tried to tunnel the femur (group I) towards 10 to 10:30 o'clock position (in the right knee) using the trans-tibial technique with the knee joint varus and internal rotation of the tibia. But using this technique, it was difficult to approximate to more oblique anatomic point. With the anteromedial portal technique (group II), it was easier to approximate to it. On the postoperative radiographs, the mean angles between the line from the intercondylar notch to the entrance of the femoral tunnel and the femoral anatomical axis were 37.2±10.5° (group I) and 48.3±8.2° (group II) (Table 2). In group I, the risk of the mismatch between the tunnel and the graft increased when we tried to reduce the angle of the femoral tunnel on the coronal plane and to approximate to more oblique anatomic point.

Minimizing the angle between the femoral tunnel and the longitudinal axis of ACL has been emphasized[15-17] and there were various trials such as the fixation of the interference screw to the femur through the femoral tunnel[18], the fixation of the interference screw through the accessory medial parapatellar portal[13], HAKI method[6], and the use of the intraoperative fluoroscory[19]. But in group II, we were able to minimize the angle between the femoral tunnel and the longitudinal axis of ACL without any additional device or technique because the positions of the knee joint were same during femoral tunneling and the fixation of the interference screw. In comparison to group I, in which the interference screw was inserted maintaining 120° or more flexion of the knee joint, in group II, the interference screw was inserted maintaining 100° flexion of the knee joint and handling was easier due to the wider visual field.

On the postoperative lateral radiographs, the femoral tunnel was parallel to the posterior cortex in group I because the femoral tunneling was performed maintaining 70~80° flexion of the knee joint. But, in group II, the femoral tunnel was perpendicular to the Blumensaat's line because the femoral tunneling was done maintaining 100° flexion and valgus of the knee joint, and external rotation of the tibia. So we were able to reduce the risk of the posterior cortical breakage in group II. But the angle between the femoral tunnel and the longitudinal axis of ACL increased in group II.

On the anteroposterior radiographs, the mean angles of the femoral tunnel and the tibial tunnel were 8.6±6.4° in group I and 17.5±5.6° in group II. On the anteroposterior and the lateral radiographs, the angle between the femoral tunnel and the longitudinal axis of ACL increased more in group II (Table 2). In an experimental study, Graf et al. reported that when the femoral tunnel was parallel to the longitudinal axis of ACL on the coronal plane, they were able to decrease the wear of ACL and that chamfering on the entrance of the femoral tunnel was useful to decrease it.

There are still controversies regarding the ideal angle between the femoral tunnel and the tibial tunnel. Min et al[20]. reported that femoral tunneling towards 11 and 1 o'clock positions through the anteromedial portal was useful with the use of PCL protector to avoid injury to PCL. However, group II in our study showed no injury to PCL without any device.

In conclusion, femoral tunneling by the anteromedial portal technique is an easy method to approximate to more oblique anatomic point. It may be performed regardless of the tibial tunnel, decrease the angle between the interference screw and ACL, reduce the risk of the posterior cortical breakage, ensure wider visual field, and reduce the mismatch between the tunnel and the graft. But, with this technique, the angle between the femoral tunnel and the longitudinal axis of ACL increases. Technical compensation with more careful chamfering and long term follow-up are needed.

Conclusion

Anteromedial portal technique is more useful for the femoral tunneling toward 10 to 10:30 o'clock (in the right knee) and 2 to 1:30 o'clock positions (in the left knee) in ACL reconstruction. With regard to the wear of the graft, long term follow-up and additional studies are needed.

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