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Original article

Comparison of transportal inside-out and outside-in femoral drilling techniques in anatomic ACL reconstruction

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Abstract

The purpose of this study was to examine tunnel length and incidence of posterior wall breakage during drilling of the femoral anteromedial (AM) tunnel in anatomic anterior cruciate ligament (ACL) reconstruction and compare those results between inside-out (transportal) and outside-in techniques. The study population comprised 68 patients (30 females and 38 males) with a mean age at surgery of 24.1 years (range, 14−45 years). In the reconstructive procedure, the femoral AM bone tunnel was drilled inside-out through the anteromedial portal in 32 knees, while the outside-in technique was employed in the remaining 36 knees. The intra-articular aperture of the femoral AM tunnel was located behind the resident's ridge in all knees as assessed by the postoperative computed tomography (CT) image. Length of the bony tunnel was measured with the depth gauge intraoperatively, while incidence of the posterior bony wall breakage (blowout) was assessed on the postoperative CT image. Thereafter, the obtained results were compared between the groups (transportal inside-out drilling vs. outside-in drilling). Knee stability was assessed at 12 months using a KT arthrometer. The mean length of the femoral AM tunnel in the inside-out group (32.2 ± 4.7 mm) was significantly shorter than that in the outside-in group (36.3 ± 4.6 mm). In the inside-out groups, posterior wall breakage was encountered in one patient (3.6%), and a lack of the tunnel length precluded the use of the EndoButton CL in three patients (10.7%). By contrast, no such complication was encountered in the outside-in group. No significant difference in knee stability was detected between the groups. During the femoral AM tunnel drilling in the current anatomic ACL reconstruction, the potential risks for the problems such as short tunnel length and posterior wall breakage were higher in the transportal inside-out drilling than the outside-in procedure. Adoption of the outside-in technique can reduce the risk of complications associated with femoral drilling.
Level of evidence: Level IV, case series.

Keywords: Anterior cruciate ligament reconstruction; Inside-out technique; Outside-in technique; Femoral tunnel

Introduction

In the anatomic anterior cruciate ligament (ACL) reconstruction, importance of reproducing native attachments of the anteromedial (AM) and posterolateral (PL) bundles has been addressed in the recent literature.[1−5] In optimization of the reconstructive procedure, therefore, option of the method for drilling the bone tunnel is a critical part of consideration. Especially, drilling procedure of the femoral tunnel is a current issue of controversy.

There have been a number of studies that have investigated the optimal drilling techniques enabling accurate and consistent graft placement while avoiding the complication during drilling.[4−8] Among the drilling procedures, inside-out transtibial and transportal techniques are commonly used in the current clinical practice. In comparison of these two techniques, in general, the AM transportal technique has been shown to be advantageous over the transtibial drilling in consistency and accuracy of graft placement.[5,6,9,10] However, increased risks of short tunnel length and posterior wall

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breakage have also been pointed out as potential shortcomings with the transportal procedure.[7,8,11]

In regards to the location of the femoral attachment site of the native ACL, there have been variable descriptions made in the previous literature.[3,12,13] Based on the results of the recent biomechanical and anatomical studies, it has been addressed that the insertion site of the femoral AM tunnel should be located behind the resident's ridge on the intercondylar fossa, and thus the intra-articular tunnel aperture is close to the posterior wall of the lateral femoral condyle (the deepest region of the intercondylar fossa in the arthroscopic view).[14,15] In this condition, risk of posterior wall breakage or shortage of tunnel length is further increased.

Outside-in technique can be another option in the drilling of the femoral bone tunnel. In this procedure, problems of shortage of bone tunnel length and posterior wall breakage can be avoided by adjusting the orientation of the drill guide. Lubowitz et al. conducted a cadaveric study comparing the femoral tunnel lengths of AM transportal and outside-in techniques. They showed that the outside-in technique resulted in a longer tunnel length than the transportal technique. However, there have been no in-vivo clinical studies comparing these two techniques in relation to the bone tunnel length and the risk of posterior wall breakage.[16]

The purpose of this study was to examine tunnel length and incidence of posterior wall breakage during drilling of the femoral AM tunnel in anatomic ACL reconstruction and compare those results between inside-out (transportal) and outside-in techniques. It was hypothesized that the outside-in procedure can provide consistent tunnel length and can reduce the risk of posterior wall breakage.

Materials and methods

Patient population

Between November 2008 and November 2009, 68 anatomical double bundle ACL reconstructions with hamstring tendon autograft were performed. Among the 68 reconstructions, the femoral AM tunnel was drilled inside-out through the portal for 32 knees, while the outside-in technique was employed for the remaining 36 knees. Selection of the drilling procedure was determined arbitrarily by the surgeon. Of the 32 knees in the inside-out (transportal) group, the far-AM (accessory) portal was utilized for 28 knees while drilling through the arthroscopic AM portal was performed for the remaining four knees. In order to avoid influences of confounding variables on the results, those with drilling through the AM arthroscopic portal were excluded from the analysis, leaving 28 knees with trans-far-AM portal drilling as the study subjects for the inside-out group. As a result, a total of 64 knees (28 and 36 knees in the inside-out and outside-in groups respectively) were included in the study. These patients were comprised of 28 females and 36 males with a mean age at surgery of 23.8 years (range, 14–45 years). No significant differences in patient group variables was detected (Table 1). Review Board of our institution approved the study protocol, and the appropriate written informed consent was obtained from all patients.

Surgical procedure

All of the surgical procedures were performed by the senior author (M.-Y.). Either semitendinosus tendon alone or semitendinosus and gracilis tendons were harvested and prepared as two-stranded grafts for each of the AM and PL bundle grafts. The femoral PL tunnel was drilled through AM portal, while the femoral AM tunnel was drilled either with transportal inside-out or outside-in procedure. For the inside-out (transportal) technique, drilling was performed through the far AM portal placed 2–3 cm medially from the arthroscopic AM portal. This portal was located just above the level of the meniscus and as medially as possible, while leaving more than 5 mm of clearance between the guide pin and the articular surface of the medial femoral condyle. During drilling, the knee was positioned to the deepest point of flexion while the arthroscopic view of the drilling site was maintained. The resultant flexion angle at drilling ranged from 123° to 135° (mean: 129.4 ± 3.8°). In the outside-in drilling, the Antero-Lateral Entry Femoral Aimer (Smith & Nephew Inc, Andover, MA, USA) was used (Fig. 1). Intra-articular insertion sites of the AM and PL grafts were determined by relying on the location of the resident's ridge as a landmark. The resident's ridge could be identified in all knees and the femoral AM tunnel aperture was placed behind the ridge. The PL tunnel was drilled at the posterior (low) and distal (shallow) position in relation to the AM tunnel while avoiding merging of the two tunnel apertures. Appropriateness of the graft insertion site location was confirmed in all knees on postoperative CT images (Fig. 2). The diameter of the bone tunnel was determined based on the corresponding graft diameter. Resultant diameter of the femoral AM tunnel ranged from 4.5 to 6.0 mm (mean: 5.4 ± 0.5 mm) and 5.0 to 6.0 mm (mean: 5.4 ± 0.3 mm) in the inside-out and outside-in groups respectively. Graft fixation was achieved by EndoButton-CL (Smith & Nephew Inc) for the femur, while the tibial side was fixed with a screw post.

Length of the bone tunnel was measured with the depth gauge (Smith & Nephew Inc) intraoperatively, while occurrence of the posterior bony wall breakage was examined on the postoperative CT images.

Postoperative stability evaluation

Stability of the ACL-reconstructed knees were assessed with a KT-1000 arthrometer (with a manual maximum stress)

Table 1
Demographic comparison between the groups.

	Inside-out group	Outside-in group	p
Male : Female	21 : 7	13 : 23	
Age (y)	23.2 ± 7.1	24.1 ± 9.6	0.774
Height (cm)	170.2 ± 7.3	166.4 ± 9.4	0.136
Weight (kg)	65.2 ± 7.6	61.2 ± 9.8	0.167

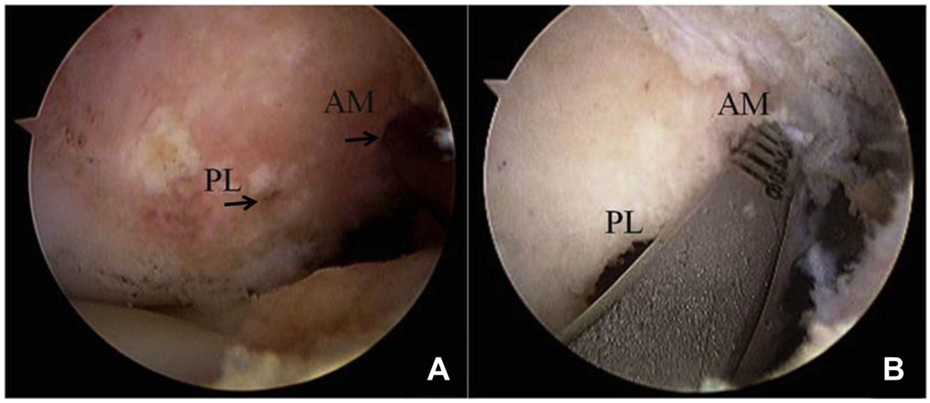

Fig. 1. The femoral AM tunnel was placed behind the resident's ridge on the intercondylar fossa (arthroscopic view through the AM portal, right knee). (A) Transportal inside-out technique drilling through the accessory portal. (B) Outside-in technique using the Antero-Lateral Entry Femoral Aimer (Smith & Nephew Inc, Andover, MA, USA).

12 months after surgery and the results were compared between the groups.

Statistical methods and power analysis

Differences of the groups were assessed using the Mann-Whitney test. The significance level was set at $p < 0.05$.

The power analysis showed that a sample size of $n = 30$ provided a statistical power of $\beta = 0.2$ at $\alpha = 0.05$ and $\delta/\sigma < 1.39$ ($\delta =$ the difference that was desired to detect, and $\sigma =$ standard deviation).

Results

The postoperative CT examination showed that intra-articular aperture of the femoral AM tunnel was located behind the resident's ridge in all knees (Fig. 2).

The mean length of the femoral AM tunnel were 32.2 ± 4.7 mm in the inside-out group and 36.3 ± 4.6 mm in the outside-in group (Fig. 3). Consequently, a statistically significant difference in the tunnel length was demonstrated between the groups ($p = 0.002$). The measured tunnel length was less than 30 mm in six patients (21.4%) and one patient (2.8%) for the inside-out and outside-in groups, respectively.

The posterior wall breakage was encountered in one patient (3.6%) and the short tunnel length and the posterior bony wall breakage precluded the use of the EndoButton CL in three patients (10.7%) in the inside-out group (Fig. 4). The fixation method was converted to screw post fixation in the one knee with posterior wall breakage, while an EndoButton with suture loop was employed for fixation in the two knees with excessive tunnel length shortage. By contrast, no such complication was observed in the outside-in group.

No serious intraoperative complications, such as neurovascular injuries, were encountered in either group. Regarding postoperative stability of the ACL-reconstructed knees, no significant difference in the KT-1000 results was detected between the groups (mean side-to-side differences of 0.79 ± 1.1 mm and 0.84 ± 1.3 mm in the inside-out and outside-in groups, respectively) ($p = 0.86$).

Discussion

The present study showed that femoral AM tunnel lengths in the inside-out group were significantly shorter and the rate

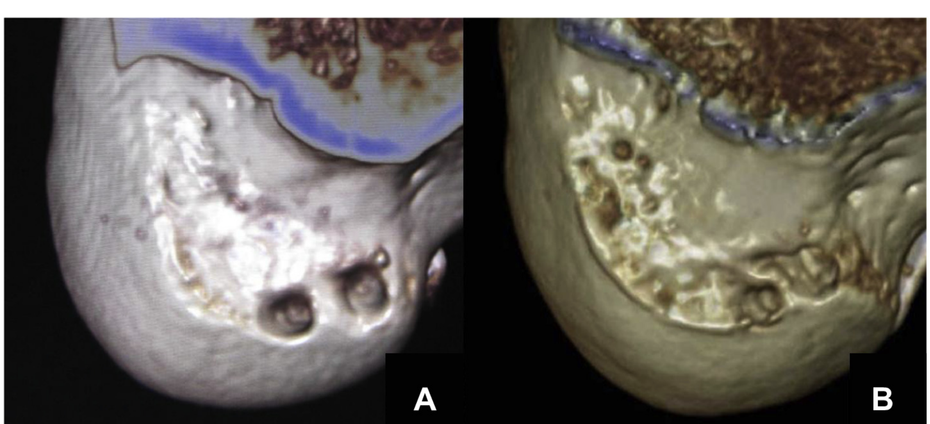

Fig. 2. Postoperative three-dimensional CT images showing intra-articular aperture of the femoral AM and PL tunnels. The AM tunnel is placed behind the resident's ridge. (A) Transportal inside-out technique. (B) Outside-in technique.

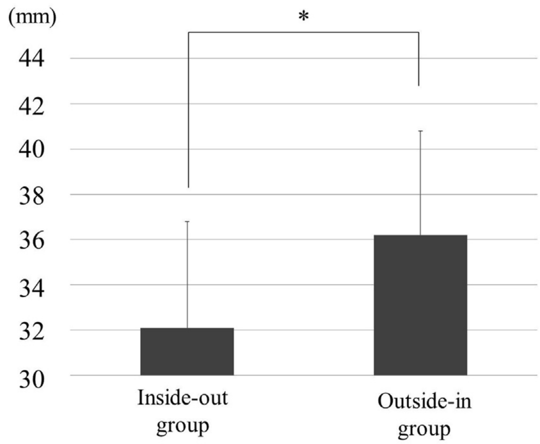

Fig. 3. Length of the femoral AM tunnel (mean ± SD) in the transportal inside-out and outside-in groups. The mean length of the femoral AM tunnel is longer in the outside-in group with a statistically significant difference ($*p = 0.002$).

of posterior wall breakage was higher than those in the outside-in group. The results of this study seem to indicate the advantage of the outside-in drilling procedure over the inside-out procedure, however; a number of other factors should also be taken into consideration in the comparative assessment of different drilling procedures. First, consistent and accurate positioning of the graft insertion site should be achieved to reproduce the physiologic anatomy and kinematics of the knee.[4,5,17,18] Second, potential risk for inadvertent injury to the posterolaterally located neurovascular structures should be minimized.[8,19,20]

Recently, there have been several anatomical studies investigating the location of the normal AM and PL bundles.[3,4,13] Based on the results of those studies, currently, the resident's ridge is proposed as a useful landmark in determining the location of the femoral bone tunnel in the anatomic ACL reconstruction.[14,15] In this situation, the bone tunnel of the femoral AM bundle is placed close to the posterior wall of the lateral femoral condyle (deepest region of the arthroscopic view field) adding to technical difficulties in graft placement as well as potential risk for posterior wall breakage.

Options of femoral bone tunnel drilling procedure are transtibial (inside-out), transportal (inside-out), and outside-in techniques. Furthermore, the transportal technique can be either through AM arthroscopic or accessory portals. Advantages and disadvantages of each of these techniques has been compared in the cadaveric and clinical investigations and reported in the previous literature.[2,5,6,9] In the majority of those studies, limitations of transtibial drilling in consistent graft placement have been reported. In our clinical practice, femoral AM tunnels had been drilled transtibially until November 2008, however; considering the results of the previous comparative studies as mentioned above, our drilling procedure for the femoral AM tunnel was switched from transtibial to either transportal inside-out or outside-in afterward.

In the transportal inside-out femoral drilling, however, the bone tunnel is oriented more horizontally than the transtibially drilled tunnel. Since the currently recommended insertion location is close to the posterior wall of the lateral condyle, this oblique tunnel orientation in the transportal drilling may increase the risk for posterior wall breakage or short tunnel length. Chang et al. raised a concern of this potential complication in the use of transportal drilling procedure based on the results of the cadaveric study.[20] They showed that the tunnel length (mean: 32 mm) in the transportal inside-out technique was significantly shorter than that in the transtibial technique (mean: 40 mm). The mean length of the AM femoral tunnel in the transportal inside-out technique in the present study was 31.8 mm, which corresponded to their results. The shortest CL length in the currently available EndoButton CL is 15 mm. If the minimal intra-tunnel graft length of 15 mm is to be warranted, a minimal 30-mm tunnel length is required. In the present series, the femoral AM length of less than 30 mm was encountered in 21.4% of the reconstructed knees in the transportal inside-out group. Moreover, Bedi et al. compared the transtibial versus AM portal procedures for femoral AM tunnel drilling in the cadaveric ACL reconstruction, and reported that the tunnel length was less than 25 mm in 41.7% of the bone tunnels drilled through AM portal and 16.7% in the transtibial group. Moreover, violation of the posterior tunnel wall was observed in 19.4% in the transportal group.[10] In our study, the posterior wall breakage was also identified on postoperative CT images in 3.6% of the knees reconstructed with the transportal inside-out technique and none in the outside-in group. These results raise a concern about the increased possibility of impaired graft fixation properties due to

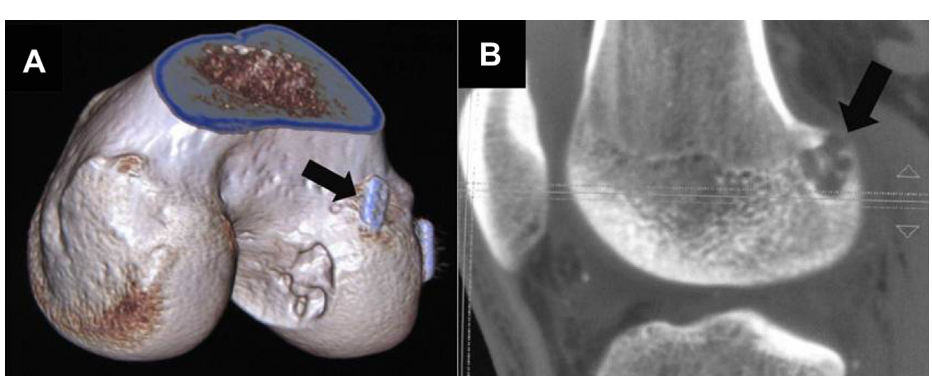

Fig. 4. Postoperative CT images showing complications in femoral drilling using the transportal inside-out technique. (A) Short femoral tunnel (black arrow). (B) Posterior wall breakage (black arrow).

the short tunnel length and the posterior wall breakage in the use of the transportal technique. In order to avoid this complication associated with the inside-out procedure, the placement of a low AM portal and drilling in deep knee flexion should be considered, as advocated by Zantop et al.[11]

In the outside-in drilling procedure, additional surgical incision through the vastus lateralis muscle is required. However, adjustment of extra-articular aperture location as well as bone tunnel orientation is feasible in this technique, and thus the risks for short tunnel length and posterior wall breakage can be minimized. The present study confirmed the consistency and safety of this procedure. Considering the results of this study as well as the previous relevant studies, the outside-in femoral drilling is thought to be superior to other drilling procedures.

There are some limitations in this study. First, the sample size is small and the selection of the two drilling procedures was not randomized in the study population. Second, the drilling procedure is not a sole determinant factor influencing the tunnel length and the rate of posterior wall breakage. Other confounding variables such as portal position, tunnel aperture position, and knee flexion angle at drilling may influence the results. Additionally, potential inaccuracy in intraoperative measurement of the tunnel length with a depth gauge can be another source of error. Therefore, the comparative results obtained in this study could not be fully validated. Moreover, influence of the short bone tunnel and occasional posterior wall breakage on the postoperative outcome needs to be examined in the subsequent clinical follow-up study.

Conclusion

During the femoral AM tunnel drilling in the current anatomic ACL reconstruction, the potential risks for the problems such as short tunnel length and posterior wall breakage were higher in the transportal inside-out drilling than the outside-in procedure. Adoption of the outside-in technique can reduce the risk of complications associated with femoral drilling.

Conflicts of interest

The authors declare that they have no financial or non-financial conflicts of interest related to the subject matter or materials discussed in the manuscript.

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