ORIGINAL ARTICLE

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Does the anteromedial portal provide clinical superiority compared to the transtibial portal in anterior cruciate ligament reconstruction in nonprofessional athletes in short-term follow-up?

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Objective: Two drilling techniques of the femoral tunnel are commonly used in anterior cruciate ligament (ACL) reconstruction: through the transtibial (TT) portal or through the anteromedial (AM) portal. The aim of the present study is to investigate the radiological and clinical outcomes of arthroscopic single-bundle ACL reconstruction using AM and TT portal techniques for drilling the femoral tunnel in nonprofessional athletes.

Methods: A retrospective review was made of 44 nonprofessional athletes undergoing ACL reconstruction using AM and TT techniques between 2011–2013. The femoral tunnel clock position on axial magnetic resonance imaging (MRI) and the anterior-posterior position of the tibial tunnel on sagittal-cut MRI scan were measured. Radiological femoral tunnel and tibial tunnel anterior-posterior inclination angles were assessed. At final follow-up, the Lachman test and pivot-shift test were used in the evaluation of the anterior-posterior stability of the knee and the rotational stability of the knee. For clinical and functional evaluation, the modified Cincinnati knee grading system, Lysholm knee scoring scale, and International Knee Documentation Committee (IKDC) form were used.

Results: No statistically significant difference was determined between the groups in terms of patient age, follow-up period, gender, and affected side distribution. There were 6 outliers in the TT group due to the clock face position. The mean femoral tunnel inclination angle was 31.07°±8.44° in the AM group and 19.02°±8.93° in the TT group. The tibial tunnel inclination angle was 21.08°±5.42° in the TT group and 16.58°±7.02° in the AM group. A statistically significant difference was determined between the 2 groups. No statistically significant difference was observed between the 2 groups in terms of Lachman test, pivot-shift test, Lysholm score, IKDC score, and modified Cincinnati score results.

Conclusion: The AM technique has no clinical superiority compared to the TT technique in ACL reconstruction in nonprofessional athletes.

Keywords: Anterior cruciate ligament; reconstruction; anteromedial portal; transtibial portal.

Level of Evidence: Level III Therapeutic Study

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Arthroscopic-assisted anterior cruciate ligament (ACL) reconstruction is 1 of the most commonly performed operations in sports medicine, and ACL reconstruction techniques continue to progress. The success of ACL reconstruction is predicated on a variety of factors. Tunnel placement plays one of the most significant roles in achieving knee kinematics and function.[1–5]

Two different drilling techniques of the femoral tunnel are commonly used in ACL reconstruction: creating the femoral tunnel through the transtibial (TT) portal or through the anteromedial (AM) portal. The conventional TT technique has been the gold standard for arthroscopic ACL reconstruction for many years, with 69–95% good clinical outcomes. However, this technique has been criticized by many authors as being a very difficult technique for placement of the tunnel in the anatomic position.[1,6,7] Bottoni[8] and Harner et al.[9] have popularized the use of the medial arthroscopic portal with the knee in hyperflexion for ACL reconstruction. Previous studies have reported that drilling the femoral tunnel through the transportal allows a more anatomical placement on the lateral femoral condyle and higher knee stability than that which can be achieved with TT reconstruction.[10,11] In a cadaveric study designed by Piasecki et al.,[12] it was concluded that femoral tunnels could be positioned in a highly anatomic manner using the TT technique but required careful choice of proximal tibial starting position, and the resulting tibial tunnel was not very practical. Traditional tibial tunnel starting points likely result in less anatomic femoral tunnels. Robert et al.[13] concluded that average percentages of the femoral tunnel within the ACL footprint were 32% for the tibial tunnel and 76% for the transportal technique.

The aim of the present study is to investigate the radiological and clinical outcomes of arthroscopic single-bundle ACL reconstruction using the TT or the AM portal technique for drilling the femoral tunnel in nonprofessional athletes. The hypothesis of this study was that there would be no significant difference between these 2 surgical techniques with regard to knee stability and knee score in patients who were nonprofessional athletes.

Patients and methods

Approval for this retrospective comparative study was granted by the local ethics committee. Informed consent was obtained from each patient. A retrospective review was made of the medical records of 44 patients (nonprofessional athletes) who underwent ACL reconstruction using the AM and TT techniques between 2011–2013. The 33 male patients played football for a maximum of 1 hour per week. The TT technique was applied to 12 patients and the AM technique to 21 patients. The 6 female patients went running for a maximum of 1 hour per week and did step aerobics for 1 hour per week. In the female patents, the TT technique was applied to 2 patients and the AM technique to 4. Inclusion criteria were as follows: patients aged 16–40 years who underwent elective primary ACL reconstruction with hamstring autogenous graft and patients who had meniscus tears needing partial meniscectomy or repair. Exclusion criteria were as follows: patients with multiligament injuries, age >40 years or <16 years, previous knee surgery on the involved knee, previous ACL reconstruction with grafts other than an autologous hamstring graft, patients with concomitant full-thickness cartilage injury which required surgery, and patients who could not undergo follow-up magnetic resonance imaging (MRI). Five patients were excluded from the study, as they had underwent previous surgery on the involved knee.

The diagnosis of ACL rupture was made by physical examination and MRI and was confirmed by arthroscopy. All surgical procedures were performed by a sports fellowship-trained orthopedic surgeon with experience in reaming both portals. Hamstring autograft was harvested from the ipsilateral knee at the beginning of the operation and woven into a 4-stranded graft. Portal placement for the AM technique was created as per the Bottoni and Harner techniques. After examination of the intra-articular pathologies, femoral and tibial ACL footprints were marked with a thermal device. Soft tissue debridement was performed only at the ACL footprint. In the TT group, the technique described by Morgan et al.[14] was used. The tibial tunnel was prepared at the footprints of the ACL at an angle of 45° to the tibial shaft. The femoral tunnel was prepared in an inside-out manner in all cases, either through the predrilled tibial tunnel for the TT group or through the AM portal for the AM group. A 5 mm offset guide was used for the preparation of the femoral tunnel with the knee at 90° flexion in the TT group, and the freehand technique was used for the preparation of the femoral tunnel in the AM group. The knee was positioned at 120° flexion by an assistant surgeon for the AM portal femoral drilling technique. The degree of flexion was measured with a sterile goniometer. After the preparation of the tunnels, the 4-stranded hamstring autogenous graft was fixed with Endobutton fixation device (ToggleLoc, Biomet, Raynham, MT) on the femoral side and with a biodegradable interference screw and staple on the tibial side. No hemovac was used in either group. The operated knee was immobilized in a hinge immobilizer.

The same postoperative rehabilitation regimen was

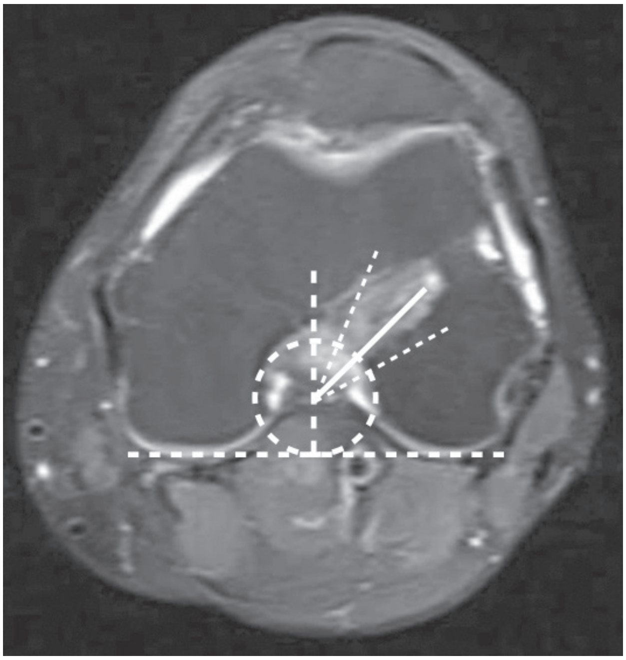

Fig. 1. Method of measuring the femoral tunnel clock position on axial-cut MRI scan in the transportal group (left knee of 25-year old male). The tunnel position was 1:45.

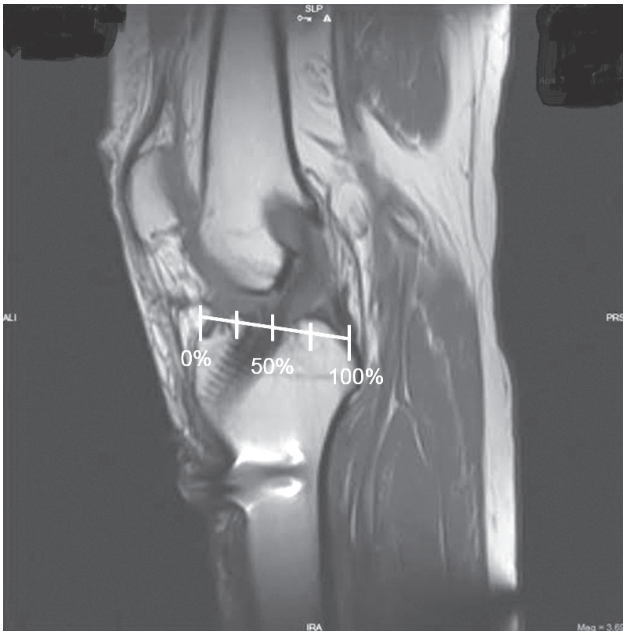

Fig. 2. Method of measuring the tibial tunnel AP position on sagittal-cut MRI scan. (right knee of 28-year old male in the TT group). The tibial tunnel position was 44% along the Amis line.

applied to all study participants. Patients were immobilized in a hinge immobilizer for 1 month. Quadriceps strengthening exercises were started on postoperative Day 1 with the assistance of a physical therapist. All patients were mobilized with 2 crutches with weight-bearing as tolerated. The participants began continuous passive motion (CPM) exercise on postoperative Day 2, and all patients were discharged on that day. All patients began active isometric motion on postoperative Day 10. All patients were referred to a sports injury rehabilitation center for their rehabilitation programs. All participants were assessed by one fellow skilled in arthroscopic ACL reconstructions.

Reassessment MRI and radiographs were taken at final follow-up after the index operation. In the evaluation of MRI images, 1.5 Tesla MRI (Philips, Amsterdam, the Netherlands) was used with 3.0 mm slice thickness. All MRI films were digitized and transferred to the picture archiving and communication system (PACS, GE Healthcare, Chicago, IL, USA) for measurement. All MRI measurements were made by a single radiologist who was blinded to the surgical technique. Repeated measurement of all films was made with at least a 1-week interval. The mean of the measurements was used to analyze the statistical difference between groups.

The femoral tunnel clock position on the axial MRI (using the modified method described by Rue et al.[15]) (Figure 1) and the anterior-posterior position of the tibial tunnel on the sagittal-cut MRI scan (using the modified Amis method[16]) were measured (Figure 2). The targeted femoral tunnel clock position was 10:30 for the right knee and 1:30 for the left knee. This was 315° in a circle for the right knee and 45° for the left knee, as described by Yau el al.[5] (Figure 3). Outliers were defined as a femoral tunnel clock position greater than 11:00 for the right knee and smaller than 1:00 for the left knee, which was equivalent to >330° for a right knee and <30° for a left knee.

Radiological femoral tunnel and tibial tunnel ante-

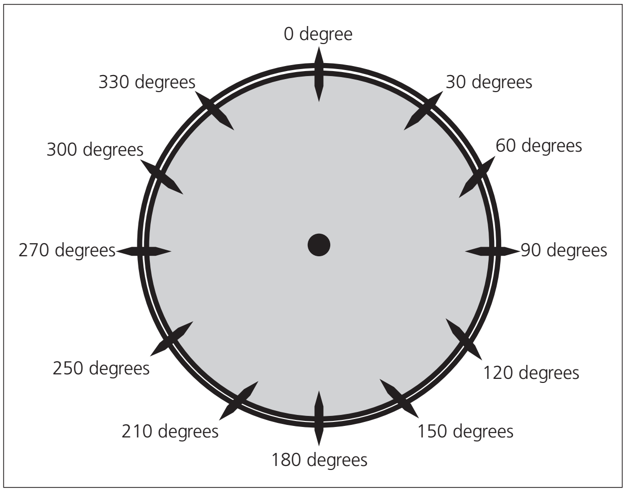

Fig. 3. Calculation of angles according to the clock position

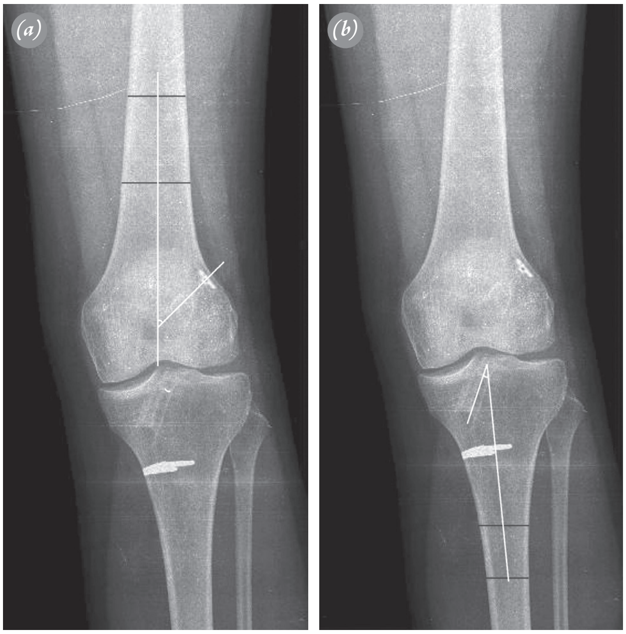

Fig. 4. **(a)** Method of measuring the femoral tunnel inclination angle. The line F represents the femoral anatomical axis, and the line T defines the line passing through the midline of the femoral tunnel. The inclination angle was defined as the bisecting of the F line with the T line. The inclination angle of this patient in the transportal group was 36.1°. **(b)** Method of measuring the tibial tunnel inclination angle. The line X represents the tibial anatomical axis, the line Y defines the line passing through the midline of the tibial tunnel. The inclination angle was defined as the bisecting of X line with Y line. The inclination angle of this patient in the transportal group was 25.8°.

rior-posterior inclination angles were assessed with the knee close to extension, and non-weight bearing images in the frontal plane, suitable for radiological assessment, were taken at follow-up examinations. The femoral tunnel inclination angle was measured as a line drawn from the center of the femoral tunnel trace on the anteroposterior (AP) radiograph, and a line was drawn as the femoral anatomical axis. The angle between these lines was described as the femoral tunnel inclination angle. The tibial tunnel inclination angle was determined in the same way as the femoral tunnel inclination angle, bisecting the line of the anatomical axis of the tibia and the line defining the center of the tibial tunnel on the AP radiograph (Figure 4a, b). All radiographic measurement assessments were made on PACS software by an independent surgeon trained in ACL reconstruction and blinded to the drilling technique. The assessor repeated the measurements at a 1-week interval. The mean of the measurements was used for analysis.

At final follow-up, the Lachman test was used in the evaluation of the anterior-posterior stability of the knee, and the pivot-shift test was used in the evaluation of the rotational stability of the knee. In the clinical and functional evaluation, the Lysholm, IKDC (International Knee Documentation Committee), and modified Cincinnati knee scoring systems were used. Anterior translation was assessed with the use of a KT-1000 arthrometer (MEDmetric Corporation, San Diego, CA, USA).

Each operated knee was compared with the contralateral knee, and according to the KT-1000, was evaluated as normal (<3 mm), near normal (3–5 mm), and abnormal (>5 mm). Of the 24 patients to whom the AM technique was applied in this study, 21 (87.5%) were normal and 3 (12.5%) were near normal. In the 15 patients to whom the TT technique was applied, 11 (73.3%) were normal and 4 (26.7%) were near normal. No patient in either group was evaluated as abnormal.

Side-to-side difference was used as an indicator of knee stability. Data from final follow-up and preoperative evaluation were used for the assessments. The occurrence and type of complications were also noted. One independent orthopedic surgeon blinded to the study design assessed the clinical outcomes with evaluation of the Lachman test and the pivot-shift test and graded them according to the modified Cincinnati, Lysholm, and IKDC scores at final follow-up.

Intraobserver reliability was assessed with the intraclass correlation coefficient (ICC) with 95% confidence interval (CI). For statistical analysis, Number Cruncher Statistical System (NCSS) 2007 software (NCSS, Kaysville, Utah, USA) and Power Analysis and Sample Size (PASS) 2008 software (NCSS, Kaysville, Utah, USA) programs were used. Descriptive statistical methods (mean, standard deviation, median, frequency, ratio, minimum, maximum) were used in the evaluation of the study data. In the comparison of quantitative data, Student's t-test was used in the comparison of the 2 groups where the parameters showed normal distribution, and Mann-Whitney U test was used where distribution was not normal. In the comparison of qualitative data, Pearson's Chi-square test and Fisher's exact test were used. Statistical significance was evaluated at levels of $p<0.01$ and $p<0.05$, respectively.

Results

Intraobserver ICCs for the assessment of the position of the femoral tunnel inclination angle, the tibial tunnel inclination angle, femoral tunnel clockwise position, and tibial tunnel position along the Amis line were 0.89, 0.88, 0.92, and 0.90, respectively.

Patients were comprised of 33 (84.6%) males and 6 (15.4%) females with a mean age of 29.31±7.02 years

Table 1. Demographics and femoral tunnel position in right and left knee.

Variables	Anteromedial (n=24)	Transtibial (n=15)	p
Mean age (yr)	29.04±7.53	29.73±6.33	[a]0.769
Gender (Male–Female)	20–4	13–2	[b]1.000
Side (Right–Left)	12–12	4–11	[b]0.150
Mean BMI (kg/m^2)	24.17±3.06	26.40±3.92	[a]0.054
Mean follow-up period (Mean±SD)	24.96±5.73	23.13±3.52	[a]0.276
Median femoral tunnel position (°)			
Right knee	305.25 (295–312.5)	326 (310–345)	[c]**0.001****
Left knee	53 (47.5–62.5)	31.25 (14.2–33.5)	[c]**0.001****

[a]Student's t-test; [b]Pearson chi-square test; [c]Mann Whitney U test; BMI: Body mass index; SD: Standard deviation; **p<0.01.

(range: 19–39 years). Mean BMI measurement was 25.03±3.54 kg/m^2 (range: 19–34 kg/m^2). Mean follow-up period was 24.26±5.02 months (range: 17–41 months). The right knee was operated on in 17 (43.6%) cases and the left knee in 22 (56.4%) cases.

Mean right knee femoral tunnel position was 311.65°±14.13° (range: 295–345°), and mean left knee femoral tunnel position was 42.71°±14.06° (range: 14.2–62.5°). No statistically significant difference was determined between the AM portal group and the TT group in terms of patient age, follow-up period, gender, and affected side distribution (p>0.05; Student's t test) (Table 1).

No statistically significant difference was determined between the AM portal group and the TT group in terms of patient gender and affected side distribution (p>0.05; Pearson's Chi-square test).

Although the BMI values of the TT operated patients were not statistically significantly different from those of the AM operated patients, a noticeably high level was determined (p=0.054; p>0.05, respectively; Student's t test).

The clock position of the AM portal group in the right knee was median 10:10 (min–max: 9:50–10:25) and 305.25° (min–max: 295.00–312.50°); clock position of the AM portal group in the left knee was median 1:46 (min–max: 1:35–2:05) and 53.00° (min–max: 47.50–62.50°). In the TT operated group, these values were median 10:52 (min–max: 10:20–11:30) and 326° (min–max: 310.00–345°) in the right knee and median 1:02 (min–max: 12:28–1:07) and 31.25° (min–max: 14.20–33.50°) in the left knee. The values were determined to be good at a statistically significant level (p<0.01; Mann-Whitney U test). When clock positions of >11:00 for the right knee and <1:00 for the left knee were accepted as outliers, a statistically significant greater number of outliers were observed in the TT group (n=6) compared to the AM group (n=0) (p=0.002; Fisher's exact test).

The mean femoral tunnel inclination angle was 31.07°±8.44° in the AM group and 19.02°±8.93° in the TT group. A statistically significant difference was determined between the 2 groups (p=0.001, p<0.05, respectively). The femoral tunnel in the AM group was determined to be more horizontal than that of the TT group. The tibial tunnel inclination angle was 21.08°±5.42° in the TT group and 16.58°±7.02° in the AM group. A statistically significant difference was determined between the 2 groups (p=0.041, p<0.05, respectively) (Table 2).

No statistically significant difference was observed between the 2 groups in respect of Lachman test (p=0.220), pivot-shift test (p=0.220), and KT-1000 (p=1.00) results (Fisher's exact test). In Lachman and pivot-shift tests, 87.5% (n=21) of the AM group patients were classified as 1+ and 12.5% (n=3) as 2+; 66.7% (n=10) of the TT group were classified as 1+ and 33.3% (n=5) as 2+.

Table 2. Femoral and tibial angles and the evaluation of differences in the angles according to the groups.

	Anteromedial	Transtibial	p
	Mean±SD (median)	Mean±SD (median)	
Femoral tunnel angle	31.07±8.44	19.02±8.93	[1]**0.001****
Tibial tunnel angle	16.58±7.02	21.08±5.42	[1]**0.041***
Tibia distance ratio	0.42±0.08	0.43±0.08	[1]**0.518***

SD: Standard deviation; [1]Student t-test; [2]Mann-Whitney U test; **p<0.01; *p<0.05.

Table 3. Lachman test, pivot-shift test and KT-1000 test at final follow-up.

Test	Anteromedial (n=24)		Transtibial (n=15)		p
	n	%	n	%	
Lachman test					[d]0.220
Negative	0	0	0	0	
1+	21	87.5	10	66.7	
2+	3	12.5	5	33.3	
3+	0	0	0	0	
Pivot-shift test					[d]0.220
Negative	0	0	0	0	
1+	21	87.5	10	66.7	
2+	3	12.5	5	33.3	
3+	0	0	0	0	
KT-1000 test					=1.000
Normal <3mm	21	87.5	11	73.3	
Near normal 3–5 mm	3	12.5	4	27.7	
Abnormal >5 mm	0	0.0	0	0.0	

[d]Fisher's exact test.

Each operated knee was compared with the contralateral knee and according to the KT-1000 was evaluated as normal (<3 mm), near normal (3–5 mm), and abnormal (>5 mm). Of the 24 patients to whom the AM technique was applied in this study, 21 (87.5%) were normal and 3 (12.5%) were near normal. In the 15 patients to whom the TT technique was applied, 11 (73.3%) were normal and 4 (26.7%) were near normal. No patient in either group was evaluated as abnormal, and no statistically significant difference was determined (p=1.00, p>0.05, respectively) (Table 3).

No statistically significant difference was determined between the preoperative clinical scores and the postoperative modified Cincinnati scores in either group (p=0.624, p=0.562, p>0.05) (Table 4). Similarly, no statistically significant difference between the preoperative Lysholm and IKDC scores and postoperative Lysholm and IKDC scores was determined in either group (p>0.05) (Table 5).

All patients returned to their preoperative occupations and resumed their previous sporting activities after 6 months. There were 2 patients (1 in each group) with superficial infection who were treated with local wound care and no antibiotherapy. No patients had extension lag or flexion contractures at final follow-up assessment. No donor site tenderness or complete graft failures were observed in either group.

Discussion

This retrospective comparative cohort study was designed to evaluate the clinical and radiological outcomes in nonprofessional athletes who underwent primary ACL reconstruction with the TT or AM portal drilling techniques. The results of this study showed that the femoral tunnels drilled through the AM portal were positioned more horizontally and anatomically, but there was no clinical superiority compared to the TT drilling group.

Recent studies have shown that more anatomically placed bone tunnels provide better kinematics of the knee and prevent graft stretching and loosening. Currently, the 2 drilling techniques used for femoral tunnel preparation are the traditional TT technique and the AM portal drilling technique. The main problem in the

Table 4. Preoperative and postoperative modified Cincinnati scores according to the groups.

Clinical score	Anteromedial	Transtibial	p
	Mean±SD (median)	Mean±SD (median)	
Preoperative	44.79±11.59	42.73±14.25	[1]**0.624**
Postoperative	82.58±5.89	81.13±9.63	[1]**0.562**
Preoperative-postoperative difference	[2]**0.001****	[2]**0.001****	

SD: Standard deviation; [1]Student's t-test; [2]Paired samples t-test; **p<0.01.

Table 5. Preoperative and postoperative Lysholm and IKDC scores according to the groups.

	Preoperative follow-up			Postoperative follow-up		
	AM	TT	p*	AM	TT	p*
Lysholm score (range)	45.87 (24–61)	44.33 (10–80)	0.515	85 (68–90)	82(59–95)	0.953
IKDC score (range)	36.74 (28–42)	33.56 (16–53)	0.107	82 (76–85)	79 (62–86)	0.307

AM: Anteromedial; TT: Transtibial; *Mann-Whitney U test.

conventional TT technique is that the femoral tunnel cannot be made independently, as the femoral tunnel aperture position is highly influenced by the position of the predrilled tibial tunnel.[17–21] Dargel et al.[6] reported that drilling the femoral tunnel through the tibial tunnel resulted in a significantly more vertical position of the femoral tunnel. In the present study, the target femoral tunnel position was ≥1:00 for left knees and ≤11:00 for right knees according to the clockwise position. The mean femoral tunnel clock wise position was 10:52 (min–max: 10:20–11:30) in the TT group and 10:10 (min–max: 9:50–10:25) in the AM group for the right knee, and 1:02 (min–max: 12:28–1:07) in the TT group and 1:46 (min–max: 1:35–2:05) in the AM group for the left knee. There were no outliers in the AM portal group, but 6 (43%) of 14 femoral tunnels in the TT group were evaluated as outliers, and a statistically significant difference was determined between the groups. This was due to the tip of the femoral guide wire being positioned more superior to the center of the femoral footprint in the TT group but placed in the exact footprint when using the transportal technique, as described in a cadaveric study which compared TT and trans-AM portal reaming.[11] Yau et al.[22] reported that the clock position of the femoral tunnel was significantly better in the transportal group. The present study confirmed the findings of Yau et al. Postoperative AP radiographic femoral tunnel inclination angle assessments also confirmed the MRI findings of the present study, that the femoral tunnel inclination angle in the AM group was more horizontal than that of the TT group.

In both groups, the tibial tunnel was drilled using the same technique. Thus, there should not have been any difference in the tibial tunnel between the transportal technique and the TT technique. The final follow-up MRI reassessments confirmed these expectations. There was no significant difference between the groups in respect to the tibial tunnel position according to the modified Amis Line (44% for TT, 42% for AM). In an MRI study comparing the transportal and TT techniques in single-bundle ACL reconstruction, the tibial tunnel was found to be 52% along the modified Amis line in the TT group and 47% along the modified Amis line in the transportal group.[22] There was a tendency for a posterior position of the tibial tunnel in the TT group, which could be related to overdrilling of the femoral tunnel through the predrilled tibial tunnel, which positioned the femoral guide wire more posterior in the tibial tunnel. The tibial tunnel inclination was more horizontal and closer to the joint line in the TT group (21.08°±5.42° for TT group, 16.58°±7.02° for transportal group). This was thought to be due to a more anatomic femoral tunnel aperture, as the tibial tunnel was used for drilling of the femoral tunnel in the TT group, but drilling of the femoral tunnel in the AM group was performed independently. Previous studies have stated that in order to position the femoral tunnel more horizontally, the tibial tunnel should also be positioned more horizontally.[23,24] In a cadaveric study by Heming et al., it was stated that to achieve a more horizontal femoral tunnel through the TT tunnel, the entrances of the tibial tunnels should be placed more horizontal and close to the joint line.[25]

In the previous clinical outcome studies of ACL reconstructions, there have been no differences in failure rates and follow-up clinical scores.[2,26] In the current study, the clinical outcomes, failure rates, and knee stability of the TT group were compared with those of the AM group, and no difference was found between the groups. This could be related to the small sample size of nonprofessional athletes. The sensitivity of the modified Cincinnati, Lysholm, and IKDC outcome measures used in this study may be too low to detect small but meaningful differences in patient outcomes. The ideal study design to compare the clinical outcomes of TT and independent drilling would be a large multicenter randomized trial.[27]

The current study had some limitations. First, it was a retrospective study with a small sample size and no randomization. Second, intraclass correlations were analyzed to assess agreement in intraobserver reliability for radiographic assessments; however, interobserver reliability for radiographic assessments was not assessed. Intraobserver reliability for clinical evaluation was not assessed, as it would not have been practical to perform the Lachman test and the pivot-shift test repeatedly in an outpatient setting during follow-up. Thirdly, the follow-up periods were too short to be able to evaluate long-term results. The relationship between position of the femoral tunnel and clinical outcomes was not investigated, but position of the femoral tunnel and clinical outcomes was compared between the 2 groups independently. Finally, MRI was used as a tool to measure postoperative tunnel position. The relative lack of precision of MRI in detecting bone pathology might have introduced significant bias over CT scans. Although CT is known as the most precise modality for evaluating the bony structure, it has the potential risk of exposure to a significant amount of radiation. Therefore, in this study MRI was preferred.

The AM independent femoral tunnel drilling technique achieved a more horizontal and anatomic femoral tunnel aperture, but the AM technique has no clinical superiority compared to the TT technique in ACL reconstruction in nonprofessional athletes as reported by these short-term follow-up results. A prospective randomized study with a 10-year follow-up period should be designed to investigate the possible differences in clinical outcomes.

Conflics of Interest: No conflicts declared.

References

1. Kopf S, Forsythe B, Wong AK, Tashman S, Anderst W, Irrgang JJ, et al. Nonanatomic tunnel position in traditional transtibial single-bundle anterior cruciate ligament reconstruction evaluated by three-dimensional computed tomography. J Bone Joint Surg Am 2010;92:1427–31.
2. Lee JK, Lee S, Seong SC, Lee MC. Anatomic single-bundle ACL reconstruction is possible with use of the modified transtibial technique: a comparison with the anteromedial transportal technique. J Bone Joint Surg Am 2014;96:664–72.
3. Loh JC, Fukuda Y, Tsuda E, Steadman RJ, Fu FH, Woo SL. Knee stability and graft function following anterior cruciate ligament reconstruction: Comparison between 11 o'clock and 10 o'clock femoral tunnel placement. 2002 Richard O'Connor Award paper. Arthroscopy 2003;19:297–304.
4. Scopp JM, Jasper LE, Belkoff SM, Moorman CT 3rd. The effect of oblique femoral tunnel placement on rotational constraint of the knee reconstructed using patellar tendon autografts. Arthroscopy 2004;20:294–9.
5. Shafizadeh S, Balke M, Kelz S, Hoeher J, Banerjee M. Low inter- and intraobserver variability allows for reliable tunnel measurement in ACL reconstruction using the quadrant method. Arch Orthop Trauma Surg 2014;134:529–36.
6. Dargel J, Schmidt-Wiethoff R, Fischer S, Mader K, Koebke J, Schneider T. Femoral bone tunnel placement using the transtibial tunnel or the anteromedial portal in ACL reconstruction: a radiographic evaluation. Knee Surg Sports Traumatol Arthrosc 2009;17:220–7.
7. Strauss EJ, Barker JU, McGill K, Cole BJ, Bach BR Jr, Verma NN. Can anatomic femoral tunnel placement be achieved using a transtibial technique for hamstring anterior cruciate ligament reconstruction? Am J Sports Med 2011;39:1263–9.
8. Bottoni CR. Anterior cruciate ligament femoral tunnel creation by use of anteromedial portal. Arthroscopy 2008;24:1319.
9. Harner CD, Honkamp NJ, Ranawat AS. Anteromedial portal technique for creating the anterior cruciate ligament femoral tunnel. Arthroscopy 2008;24:113–5.
10. Azboy I, Demirtaş A, Gem M, Kıran S, Alemdar C, Bulut M. A comparison of the anteromedial and transtibial drilling technique in ACL reconstruction after a short-term follow-up. Arch Orthop Trauma Surg 2014;134:963–9.
11. Bedi A, Musahl V, Steuber V, Kendoff D, Choi D, Allen AA, et al. Transtibial versus anteromedial portal reaming in anterior cruciate ligament reconstruction: an anatomic and biomechanical evaluation of surgical technique. Arthroscopy 2011;27:380–90.
12. Piasecki DP, Bach BR Jr, Espinoza Orias AA, Verma NN. Anterior cruciate ligament reconstruction: can anatomic femoral placement be achieved with a transtibial technique? Am J Sports Med 2011;39:1306–15.
13. Robert HE, Bouguennec N, Vogeli D, Berton E, Bowen M. Coverage of the anterior cruciate ligament femoral footprint using 3 different approaches in single-bundle reconstruction: a cadaveric study analyzed by 3-dimensional computed tomography. Am J Sports Med 2013;41:2375–83.
14. Morgan CD, Kalman VR, Grawl DM. Definitive landmarks for reproducible tibial tunnel placement in anterior cruciate ligament reconstruction. Arthroscopy 1995;11:275–88.
15. Rue JP, Lewis PB, Parameswaran AD, Bach BR Jr. Single-bundle anterior cruciate ligament reconstruction: technique overview and comprehensive review of results. J Bone Joint Surg Am 2008;90 Suppl 4:67–74.
16. Amis AA, Jakob RP. Anterior cruciate ligament graft positioning, tensioning and twisting. Knee Surg Sports Traumatol Arthrosc 1998;6 Suppl 1:2–12.
17. Abebe ES, Moorman CT 3rd, Dziedzic TS, Spritzer CE, Cothran RL, Taylor DC, et al. Femoral tunnel placement during anterior cruciate ligament reconstruction: an in vivo imaging analysis comparing transtibial and 2-incision tibial tunnel-independent techniques. Am J Sports Med 2009;37:1904–11.
18. Arnold MP, Kooloos J, van Kampen A. Single-incision technique misses the anatomical femoral anterior cruci-

ate ligament insertion: a cadaver study. Knee Surg Sports Traumatol Arthrosc 2001;9:194–9.
19. Gadikota HR, Sim JA, Hosseini A, Gill TJ, Li G. The relationship between femoral tunnels created by the transtibial, anteromedial portal, and outside-in techniques and the anterior cruciate ligament footprint. Am J Sports Med 2012;40:882–8.
20. Larson AI, Bullock DP, Pevny T. Comparison of 4 femoral tunnel drilling techniques in anterior cruciate ligament reconstruction. Arthroscopy 2012;28:972–9.
21. Miller MD, Gerdeman AC, Miller CD, Hart JM, Gaskin CM, Golish SR, et al. The effects of extra-articular starting point and transtibial femoral drilling on the intra-articular aperture of the tibial tunnel in ACL reconstruction. Am J Sports Med 2010;38:707–12.
22. Yau WP, Fok AW, Yee DK. Tunnel positions in transportal versus transtibial anterior cruciate ligament reconstruction: a case-control magnetic resonance imaging study. Arthroscopy 2013;29:1047–52.
23. Chhabra A, Diduch DR, Blessey PB, Miller MD. Recreating an acceptable angle of the tibial tunnel in the coronal plane in anterior cruciate ligament reconstruction using external landmarks. Arthroscopy 2004;20:328–30.
24. Howell SM, Gittins ME, Gottlieb JE, Traina SM, Zoellner TM. The relationship between the angle of the tibial tunnel in the coronal plane and loss of flexion and anterior laxity after anterior cruciate ligament reconstruction. Am J Sports Med 2001;29:567–74.
25. Heming JF, Rand J, Steiner ME. Anatomical limitations of transtibial drilling in anterior cruciate ligament reconstruction. Am J Sports Med 2007;35:1708–15.
26. Zhang Q, Zhang S, Li R, Liu Y, Cao X. Comparison of two methods of femoral tunnel preparation in single-bundle anterior cruciate ligament reconstruction: a prospective randomized study. Acta Cir Bras 2012;27:572–6.
27. Riboh JC, Hasselblad V, Godin JA, Mather RC 3rd. Transtibial versus independent drilling techniques for anterior cruciate ligament reconstruction: a systematic review, meta-analysis, and meta-regression. Am J Sports Med 2013;41:2693–702.