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Antero-medial portal vs. transtibial techniques for drilling femoral tunnel in ACL reconstruction using 4-strand hamstring tendon: A cross-sectional study with 1-year follow-up

Mohsen Mardani-Kivi^{ABDEF}, Firooz Madadi^{BD}, Sohrab Keyhani^{BD},
Mahmoud Karimi-Mobarake^{BD}, Keyvan Hashemi-Motlagh^{CEF},
Khashayar Saheb-Ekhtiari^{GEF}

Orthopedic Research Center, Orthopedic Department, Poursina Hospital, Parastar Street, Rasht, Guilan, Iran

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Background:

Summary

Antero-medial portal (AMP) and trans-tibial (TT) techniques are the most widely used methods for drilling femoral tunnel in ACL reconstructions; yet, debate continues about the preferred method. This study seeks to compare these 2 techniques in patients with ACL tears.

Material/Methods:

In this comparative study, all cases of isolated ACL reconstruction using 4-strand hamstring tendon in 2006–2010 were evaluated for eligibility. Of 266 patients, 124 cases (60 TT and 64 AMP), with the mean age of 28.48±8.3, met the inclusion criteria. Both groups were compared in 8 follow-ups from the point of view of time of: return to post-surgical activities (including walking without crutches, normal life activity, jogging, and exercising), maximum range of passive movements, knee instability (Lachman test), functional condition (subjective IKDC and Lysholm knee scores), therapeutic outcomes, and patient's satisfaction with treatment (VAS).

Results:

AMP technique significantly accelerates patients' return to activity. AMP patients achieved full range of motion much sooner than TT cases ($P<0.0001$). After 1-year follow-up, S-IKDC scores were 94.8±3.9 and 89.2±4.1 and S-LKS scores were 96.1±3 and 92.2±4.1 for AMP and TT groups, respectively ($P<0.0001$). Knee stability was similar in both groups on Lachman test ($P=0.25$). AMP group patients (VAS mean score: 9.78±0.4) had greater satisfaction compared to TT group patients (VAS mean score: 9.53±0.5) ($P=0.003$).

Conclusions:

AMP technique leads to reduction in time to return to routine activities, better therapeutic outcomes and higher satisfaction rates.

key words:

arthroscopic procedure • anterior cruciate ligament • femoral tunnel • antero-medial portal • transtibial portal

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Author's address:

Mohsen Mardani-Kivi, Orthopedic Research Center, Orthopedic Department, Poursina Hospital, Parastar Street, Rasht, Guilan, Iran, e-mail: dr_mohsen_mardani@yahoo.com or mardani@gums.ac.ir

BACKGROUND

The 175,000 injured ACLs that are annually reconstructed in the United States cost more than 1 billion dollars [1–4]. Despite all discrepancies in ACL reconstruction, techniques of femoral drilling are still the most important discussion in arthroscopically-assisted ACL reconstruction [1,5,6]. Currently, the 2 main fixation methods used by surgeons are trans-tibial (TT) and antero-medial portal (AMP) [5]. Hardin et al delineated femoral tunnel drilling through trans-tibial technique and Battoni et al described AMP method for the first time in 1998 [7]. The TT technique precluded the necessity for the lateral incision of the 2-incision technique (creation of femoral tunnel outside-in) and potentially decreased the time of surgery and perioperative complications [8]. However, recent studies emphasize that the TT method leads to increased instability in anterior-posterior and rotational movements because of drilling non-anatomic femoral tunnels [6,9–16]. In addition, in this method the surgeon has less chance to alter orientation and positioning of the femoral tunnel [17]. To solve these problems and achieve optimal femoral tunnel obliquity, Howell et al suggested creating the tunnel at a coronal angle of 65° to 70° [18]. In their technical note, Chhabra et al. described a method of creating the tibial tunnel by using bony landmarks (a tibial starting point at the midpoint between the tibial tubercle and postero-medial corner) [19]. In a recent study, Bowers et al. compared AMP and TT techniques using 3-dimensional magnetic resonance imaging, and found that both techniques can create the native femoral footprint with similar accuracy. However, they showed that the TT method results in decreased sagittal graft obliquity [20]. It has been anticipated that ACL reconstruction using the antero-medial portal (AMP) method potentially restores more stability, especially in rotational movements [6]. Moreover, this technique creates a more anatomic site for femoral attachment of the ACL [9,21–23]. Bedi et al. demonstrated that the marginal gain in potential obliquity of about 7° by the AMP technique may be accompanied by an increased risk of complications, including a tunnel with short length and posterior tunnel wall blow-out [24].

Since in TT method the femoral tunnel is inevitably affected by angle and position of the tibial tunnel, a more vertical femoral tunnel is created and the surgeon has less chance for changing positioning and orientation of the femoral tunnel. AMP technique provides the surgeon with more freedom to create a more horizontal tunnel and better tunnel orientation to the ACL footprint and anatomic position as much as possible [21,22]. Giron et al. and Rue et al. believe that a relatively independent femoral tunnel placement is possible with TT drilling [11,12].

The majority of papers have dealt with the comparison of functional and clinical outcomes of these 2 methods using the BPTB tendon [1,6,12,22–28]. To our knowledge, there is no study comparing functional and clinical outcomes of AMP and TT techniques using 4-strand hamstring tendon. This study dealt with the comparison of functional-clinical outcomes of TT and AMP techniques in arthroscopically-assisted ACL reconstruction using 4-strand hamstring autograft, and reviewed similar previous papers.

MATERIAL AND METHODS

The University's research deputy approved the conduct of this analytical comparative study. All patients who underwent unilateral arthroscopically-assisted ACL reconstruction using 4-strand hamstring graft (4S-HG) were evaluated for eligibility. Among these, adult patients ages 16–55 who had isolated unilateral ACL rupture were included in the study. Inclusion criteria were: history of giving-way, a positive Lachman test (grade >3+), confirmation of ACL rupture with magnetic resonance imaging, and 3 weeks to 6 months interval between injury and surgery. Patients having rupture in other knee ligaments, meniscus rupture, synovitis, and or previous knee surgery were excluded. Informed consent was obtained from all qualified patients in the first follow-up session after giving adequate information about the research. All operations were performed by a knee arthroscopy fellowship orthopedist (the corresponding author) with a 4-strand hamstring autologous graft (2 strands of gracilis tendon graft plus 2 strands of semitendinosus tendon graft). All operations were different only in femoral tunnel drilling technique. From the beginning of the research to July 2008, trans-tibial tunnel (TT) drilling method was used, and after this date antero-medial portal (AMP) technique was performed. In order to eliminate learning curve effect, patients operated on in the first 4 months of beginning AMP method were not included in the study. Among 266 patients who underwent ACL reconstruction through 4-strand hamstring tendon, 135 patients were qualified (131 patients had meniscus and/or other ligaments tears besides ACL rupture); 11 patients were excluded from the study since they were not accessible. Finally, from 124 qualified patients, 60 patients were in the transtibial group and 64 patients were in the antero-medial portal group.

Surgery technique

Four-strand hamstring tendon including a folded gracilis tendon and a 2-ply semitendinosus tendon was used in all operations. The average diameter of 4S-HG was 7.8 ± 0.8 with range of 7–9 millimeter and the average length of grafts was 12.1 ± 1.2 centimeter (9–14 centimeter). Antero-lateral standard portal was used for arthroscopic lens and antero-medial portal for the other instruments. The stump of ACL to tibia and femur was manipulated as little as possible. At this stage, procedures in both groups were identical.

In the TT method, after flexing the knee up to 90°, a tibial jig inserted from the antero-medial portal was used in order to subsequently drill the guide pin, and a reamer appropriate to graft diameter was used to create the tibial tunnel. Then, the knee was flexed to 110° and the femoral tunnel portal was positioned and drilled in 11 o'clock for the right knee (1 o'clock for the left knee) in over-the-top area. In the AMP technique, using an antero-medial portal, as the knee was flexed between 120–135 degrees, the femoral tunnel portal was positioned between 9 and 10 o'clock for the right knee (2 and 3 o'clock for left knee), and a guide pin was drilled. Next, a femoral tunnel was first reamed with a 4-milimeter drill for proximal and distal cortex and then the femoral tunnel was drilled appropriate to graft diameter. Finally, a tibial tunnel was drilled exactly as in the TT technique (Figure 1). For graft fixation, absorbable interference screws and Endo-button were used in the

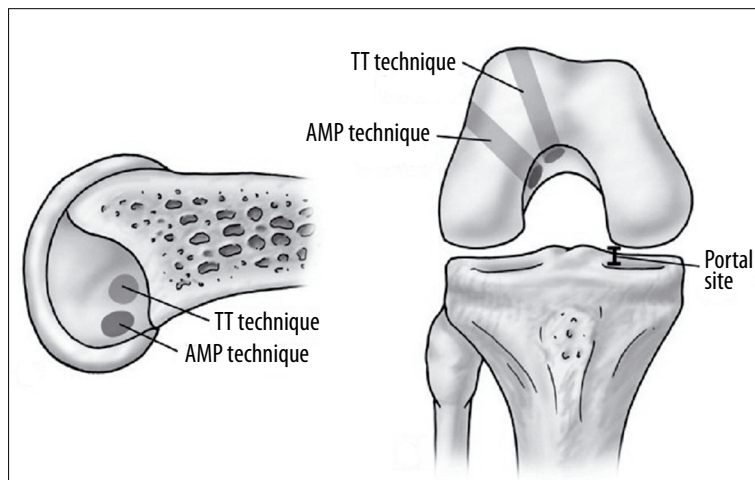


Figure 1. (A) Lateral and (B) Anterior view of the knee illustrating the femoral tunnel. AMP technique vs. TT technique.

tibial and femoral sides, respectively. In all cases the diameters of applied screws were selected 2 millimeter larger than tunnel diameter.

Postoperative rehabilitation

Both group underwent Hemovac knee drainage for 48 hours post-operatively and parenteral first generation cephalosporin (Cephazolin). The same postoperative regimen was followed in both groups. Active and passive 90° knee flexion and active quadriceps exercise were encouraged immediately from the first postoperative day. At 2 weeks after surgery, patients were allowed to walk with partial weight bearing and enrolled in a supervised basic program of physiotherapy [29,30]. A knee brace was worn for 3 weeks. Patients were allowed to perform full flexion and complete weight bearing at 4 weeks postoperatively and jogging was permitted at 4 months. No specific time limits were set on return to running or sports.

Patients were followed up at 8 intervals (biweekly for the first 2 months, monthly from month 3 to 6, and 1 year post-operation). They were evaluated in terms of timing of return to post-op activities, including 1) walking without crutches, 2) normal life activity, 3) jogging, and 4) training). In these follow-ups, maximum range of passive movements in knee flexion and extension was recorded. To determine clinical outcome, Lachman test was performed by another orthopedist and was recorded in the form of grading from 0 to +3.

Functional treatment outcome was determined using the Subjective Lysholm Knee Score (S-LKS) and Subjective International Knee Documentation Committee (S-IKDC) (31). Patient satisfaction with treatment efficacy was decided using the Visual Analogue Score (0 equals complete non-satisfaction and 10 equals complete patient satisfaction with treatment).

Statistical analysis

Demographic characteristics (age and sex) and the above criteria were recorded and were statistically analyzed using SPSS software package for windows v. 19.0 (SPSS Inc., Chicago, IL, USA). After summarizing the characteristics of both groups with descriptive statistics, response variables were evaluated according to the Kolmogorov-Smirnov test

and it was shown that none had a normal distribution; therefore, the Mann-Whitney U test was used in order to compare these variables of both groups. Chi-square test was used to compare the differences of grading in Lachman test. To analyze the trend of ROM changes, SKLS, S-IKDC, and VAS, "repeated measure analysis" through Muchley's test of Sphericity was employed, and variance analysis was performed to evaluate the value of these changes. In all statistical tests, the alpha level was set at 0.05. The study protocol conformed to the ethics guidelines of the 1975 Declaration of Helsinki as reflected in prior approval by the appropriate institutional review committee. Before beginning the treatment, therapeutic protocols and their advantages and disadvantages were completely explained to all patients orally and informed consent was obtained.

RESULTS

Of 124 observed cases, 107 were male (86.3%) and 17 were female (13.7%). The mean age of the patients was 28.48±8.3 years (range of 16–52 years); among these, 54 cases (43.5%) were in the age range of 21–30 years. Patient age and sex frequency distribution was not considerably different in the 2 observed groups ($P=0.78$ and $P=0.35$, respectively).

Using the Mann-Whitney U test, comparison of the mean and grading of recovery time from surgery in the 2 groups demonstrated that the AMP method significantly reduced the time of return to all types of patient post-surgical activities (Table 1).

Statistical analysis illustrated that trend of changes in knee ROM over time is significantly different between the AMP and TT techniques. This means that the values of measured angles from the beginning of follow-ups are closer to normal value in AMP-group patients, and knee ROM (whether in extension or in flexion) reaches the normal values sooner than in the TT group ($P < 0.0001$).

To determine S-KLS and S-KIDC criteria, patients were examined at 6 and 12 months. In 6th-month visit, the mean of S-KIDC score was 89.9±4.3 for the AMP group and 83.7±5.5 for the TT group. These values had a remarkable improvement in the 12th month and reached 94.8±3.9 and 89.2±4.1 for AMP and TT groups, respectively. S-KLS mean (at

Table 1. Comparison of time of return to post surgical activity, for two groups separately.

	Antero-medial portal	Trans tibial	Level of sig.
	Median (mean \pm std dev)	Median (mean \pm std dev)	
Walking with crutches	4 (4.31 \pm 0.59)*	5 (5.07 \pm 0.88)	P<0.0001
Normal activity**	7 (7.14 \pm 1.44)	8 (8.68 \pm 1.80)	P<0.0001
Jogging	12 (11.72 \pm 1.98)	14 (14.57 \pm 3.02)	P<0.0001
Training	20 (20.62 \pm 2.71)	24 (23.87 \pm 2.33)	P<0.0001

* All mentioned times are from the beginning of surgery to the time of return to activity, and have been given in weeks; ** normal activity means that patient returns to previous routines and again goes to work.

6-month follow-up) was 93.8 \pm 3.4 for the AMP group and 89.3 \pm 5.6 for the TT group. In the 12th month, this criterion showed that patients had assigned very higher scores to the function of the reconstructed knee; AMP and TT groups' means were 96.1 \pm 3 and 92.2 \pm 4.1, respectively. Variance analysis test demonstrated that "values" of these 2 criteria in the AMP group were remarkably higher than in the TT group (P<0.0001). However, results of Muchley's test demonstrated that none of these criteria were different in terms of "change-trend" (P<0.41 and P<0.26, respectively).

Stability of reconstructed ligaments in both groups was assessed using Lachman test. In the AMP group, 47 patients (73.4%) rated 0, and 17 cases (26.6%) rated 1; in the TT group, 38 knees (63.3%) and 22 knees (36.7%) were rated at 0 and 1 degrees, respectively. It was determined that both techniques equally improved knee stability (P=0.25). Finally, patient satisfaction with the performed operation and treatment efficacy in both groups were compared via VAS scale at 6 and 12 months. The VAS mean at the 6 month visit for the AMP group was 9.72 \pm 0.5, higher than the TT group mean, which was 9.38 \pm 0.7 (P=0.002). At the last follow-up, VAS means for the AMP and TT groups were 9.78 \pm 0.4 and 9.53 \pm 0.5, respectively (P=0.003). Values of patient satisfaction were significantly different and variance analysis confirmed that the AMP group had greater satisfaction with treatment (P=0.001).

DISCUSSION

In the last decade BPTB autograft has become more acceptable than hamstring graft; therefore, most studies compared the femoral tunnel drilling methods with this tendon [1,6,12,22,23-28,32]. In this study, we decided to analyze clinical and functional outcomes of the AMP and TT techniques in ACL arthroscopic reconstruction using the 4S-HG tendon.

In a review article, Alentorn-Geli et al. considered 21 papers (859 knees) about femoral tunnel drilling in ACL reconstruction with BPTB [1] and determined that the AMP group starts jogging notably sooner than the TT group. In our study, return to all kinds of activities was faster in the AMP group; it seems that this method may be helpful in reduction of economic burden arising from prolonged treatment duration of this injury by decreasing recovery time from surgery. Both in our study and in this review article, in short-term follow-ups (6-12 months) knee ROM is remarkably better with the AMP method compared to the TT method; but there is no significant difference in long-term follow-ups (3-5 and

6-10 years) [1]. This may explain the AMP group's quicker return to routine and sport activities, demonstrating that the more anatomic position of the tendon graft leads to less challenged knee ROM. Considering knee laxity, studies with short-term follow-up confirmed obvious advantage of AMP compared to TT; but again, in long-term follow-ups this superiority disappeared. The anterior-posterior instability of the knee in TT may be because the femoral graft is placed in a more-anterior position than in native ACL.

To evaluate functional outcomes, we used S-IKDC and SKLS knee forms and found that in both criteria the AMP method achieved better scores. Analyzing the trend of these criteria, it was determined that as time passes, therapeutic outcomes become better. In the above-mentioned review article [1] no significant difference was observed between AMP and TT methods in the total 409 patients evaluated using the S-IKDC scale. This is probably due to, the surgeon's precision and experience, especially in execution of the AMP technique, which is a more difficult and more challengeable method. In addition, using the hamstring tendon leads to more effective synovial coverage [33] may be another reason for this paper's better therapeutic outcomes compared to other studies that have used BPTB grafts. Patient satisfaction data using the VAS criterion demonstrated that patients in the AMP group were more satisfied than those in the TT group, which may be related to faster return to routines.

The results of ACL arthroscopic reconstruction using TT and AMP methods have been compared in various types of investigations (from cadaveric to imaging studies and research on patients and athletes), but surgeons have not yet demonstrated the clear superiority of one method over the other [12-15,21-23,25,28,32].

In recent years, *in vitro* cadaveric investigations had a major contribution to research on ACL reconstruction. In 2008 Gavrilidis et al conducted their study on 10 cadavers in order to compare TT and AMP techniques in terms of anatomic position of femoral tunnel placement. They demonstrated that drilling a tunnel using the AMP technique is more accurate than the TT technique [23]. In another study on 18 cadavers, these 2 methods were compared from the point of view of tunnel length and obliquity [24]. Bedi et al. concluded that the AMP method can enable the surgeon to drill a more oblique tunnel, but this method causes the tunnel to be shortened and may lead to the tunnel's posterior wall blow-out [24]. Bedi et al., in their newer study on 10 cadavers in

2011, evaluated biomechanical and anatomical outcomes of these 2 methods in ACL reconstruction; again, the ultimate result indicated the superiority of the AMP method [34]. Albuquerque et al conducted a similar comparison on 20 cadavers in Brazil., concluding that both methods could obtain appropriate position of the femoral tunnel for the surgeon. Their evaluation supports the AMP method because it provides more protection against posterior wall destruction [35].

A series of studies have compared these techniques through imaging methods. Iwame et al dealt with evaluation of femoral tunnel angle using 3-dimensional CT scan in a randomized clinical trial on 31 patients. They demonstrated that drilled femoral tunnels using the AMP method were considerably more vertical in sagittal plane and closer to the posterior cortex. They concluded that although tunnel length with the AMP method was shorter, it rarely was less than 30mm, and it can be used as an efficacious and safe method in drilling femoral tunnels [36].

An ACL arthroscopic reconstruction can be considered successful when perfect similarity is created between reconstructed and native ACL in terms of place, position, and correct orientation of the graft. Alentorn-Geli, in a similar study with BPTB graft, recently concluded that AMP technique prominently restores higher knee stability in rotational and anterior-posterior movements [6]. In a study by Chao et al, these 2 methods were compared in a retrospective study, demonstrating that the AMP method enables the surgeon to drill a more posterior and more inferior (more anatomic) femoral tunnel compared to the TT method [37].

Paessler et al. showed that femoral tunnel drilling using TT did not create an anatomic place of ACL, even in cases where a wider tibial tunnel was drilled (for hamstring tendon >8.5 mm). They were convinced that the AMP method is essential for tunnels less than 9 mm diameter [15]. In addition, Heming et al concluded that the TT technique has the capability of femoral tunnel drilling, but it may lead to disproportion "tunnel length-tendon length" or debilitation of graft fixation [13]. Although most recent papers have supported the AMP method and refer to its superiority over the TT method, TT technique should not be abandoned just because of the results of this and a few other studies.

Although we used 4-strand hamstring graft in this study, our general results are similar to other papers in which the AMP method with other tendons has been used [1,38-42]. The important point is that despite the difference of graft type in our study and other studies, similar clinical and functional outcomes were achieved. This indicates that in femoral tunnel drilling using the AMP technique, aside from graft type (BPTB or hamstring graft), similar results are achieved and the type of tunnel drilling has a much more important role in determination of functional and clinical outcome compared to graft type. Of course, graft type has its own advantages and disadvantages [33,43].

AMP technique in ACL reconstruction, like other surgical procedures, has advantages and disadvantages. Its advantages include the following: 1) tunnel drilling using the AMP method is an unconstrained option compared to TT method, and in double-bundle reconstructions, in order to drill postero-lateral and antero-medial tunnels anatomically, it

should be utilized; 2) it is the best method for prevention of divergence and redirection of a tunnel when cannulated interference screws are used for fixation (since both reaming and screwing are performed via the very antero-medial portal); and 3) if revision is needed, this technique is more helpful and more efficacious than the TT method [28]. Its disadvantages include: 1) blowout of posterior wall of femoral intercondylar notch; 2) inability to maintain useful vision in knee hyper-flexion position; and 3) difficulties in passing graft or fixation tools [28]. One of its very rare complications is femoral guide breakage; 1 case of this was reported by Milankov et al in 2009 [43].

It should be acknowledged that one of the limitations of this study was non-availability of KT-1000, so clinical examination in our study was only qualitative. Short-term follow-up of the study should be mentioned as another limitation, because long-term studies (3-5 years and 6-10 years) [1,6] illustrated that some variables (including ROM and joint stability rate) reach an approximately similar rate in both groups over time in amelioration process, in which the TT group did as well as the AMP group. Both groups were not completely homogeneous and were not matched in terms of type of sport (contact or non-contact) or type of work and daily activity, which could decrease the internal validity. However, with regards to the 1-year follow-up of the study, the above-mentioned variables would not practically impact the functional outcomes of the study. We are also aware that the lack of independent examiner in this study may cause surveillance bias. However, a major strength of the present study is that it reports the experience of a single center, single surgeon, same graft, and similar rehabilitation program. The observed population in most previous studies was cadavers or special populations like athletes. Among the strengths of this study - concerning appropriate number of samples in all age and job categories - is that this research has the capability to be expanded to the general population. In addition, although using hamstring tendons has become more acceptable than in the past, there is still a lack of relevant studies. What distinguishes this study from previous ones is using the hamstring tendon in ACL reconstructions, and the comparison of AMP and TT methods. Long-term comparative studies and randomized trials with strict inclusion and exclusion criteria and a larger sample size should be conducted in order to determine the preferable technique.

CONCLUSIONS

Using AMP technique results in better clinical outcomes and greater patient satisfaction rates, as well as reducing time of return to routine activities.

Conflicts of interest

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