All-Inside Single-Bundle Reconstruction of the Anterior Cruciate Ligament with the Anterior Half of the Peroneus Longus Tendon Compared to the Semitendinosus Tendon: A Two-Year Follow-Up Study

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J Knee Surg

Abstract

The anterior half of the peroneus longus tendon (AHPLT) has been reported to be acceptable for ligament reconstruction with respect to strength and safety. However, there is little information regarding the clinical outcomes after using the AHPLT compared with other autograft tendons. A prospective randomized controlled study was performed to compare the results of 62 cases of all-inside anatomical single-bundle anterior cruciate ligament (ACL) reconstruction using the AHPLT and 62 cases using semitendinosus graft with an average of 30.0 ± 3.6 months' follow-up. Tunnel placements of enrolled cases were measured on three-dimensional (3D) computed tomography (CT) and X-ray imaging. Knee stability was assessed using the anterior drawer test, pivot shift test, and KT-1000. The International Knee Documentation Committee (IKDC) 2000 subjective score was used to evaluate functional outcomes. The American Orthopedic Foot and Ankle Score (AOFAS) and the assessment of eversion muscle strength were performed to evaluate the function of the ankle donor site. Tunnel positions, which were confirmed with 3D CT, were in the anatomical positions. At the final follow-up, there were no significant differences between the semitendinosus group and the AHPLT group in the IKDC score (90.4 ± 7.1 vs. 89.3. ± 8.4), KT 1000 measurements (1.71 ± 0.57 vs. 1.85 ± 0.77), pivot shift test, and Visual Analogue Scale (VAS) (0.15 ± 0.36 vs. 0.10 ± 0.30). No obvious ankle site complications were found at 24 months. The average AOFAS score of the AHPLT group was comparable to that of the semitendinosus tendon group (99.1 ± 1.40 vs. 99.5 ± 1.21). There was no significant difference in clinical outcomes or knee stability between the semitendinosus group and the AHPLT group at the 2-year follow-up. An AHPLT autograft may be a good alternative for all-inside ACL reconstruction with respect to its strength, safety, and donor site morbidity.

Keywords
- anterior cruciate ligament
- all-inside
- peroneus longus tendon
- donor site

Recently, anatomical anterior cruciate ligament (ACL) reconstruction has been the standard surgical treatment for ACL rupture. Both single- (SB) and double-bundle (DB) anatomical ACL reconstruction showed good knee stability and kinematics.[1–3] The anatomical tunnel position is believed to be the key to excellent results of this operation[4–7] as the malposition of

received
June 19, 2017
accepted after revision
January 7, 2018

DOI https://doi.org/10.1055/s-0038-1627466.
ISSN 1538-8506.

bone tunnels may result in abnormal knee kinematics, stretching of grafts, or graft impingement.[8,9] Semitendinosus and gracilis grafts are commonly used in all-inside ACL reconstruction[10–12]; however, the size of the hamstring tendons may differ between individuals.[13–15] Patients weighing less than 50 kg, less than 140 cm in height, with a thigh circumference of less than 37 cm, and having a body mass index of less than 18 should be considered to be at high risk for unqualified hamstring tendons.[15] Thus, autograft shortages are usually encountered in clinical practice, especially for DB ACL reconstruction or simultaneous SB ACL reconstruction and posterior cruciate ligament (PCL) reconstruction. In these instances, a supplementary graft is needed. The peroneus longus tendon (PLT) has been reported as an ideal autograft choice for ligament reconstruction, but there is little information regarding the clinical outcomes using the PLT or the anterior half of the peroneus longus tendon (AHPLT) autograft. To our knowledge, there are only five studies in the literature investigating the use of these grafts[16–20]; however, these are all case series studies based on small sample sizes. Importantly, there were no other autograft tendons used for comparison, which may lead to a potential bias that makes the conclusion precarious. Therefore, we are interested in investigating whether the clinical outcomes of the PLT autograft were equivalent to the other grafts. We used the semitendinosus graft for a comparison since the gracilis tendon may not be strong enough for a graft.[19,21]

The PLT plays an important role in the function of the foot and ankle.[22–26] Total removal of the PLT may result in the dysfunction of the peroneus longus muscle;[20] thus, we only used the anterior half of the PLT to avoid the possible loss of ankle function. Considering the possible inadequate length or diameter of the harvested tendons, we choose the all-inside technique to perform this comparison.[27,28] The purpose of this study is to determine whether the anterior half of the PLT is suitable for all-inside anatomical SB ACL reconstruction to restore the stability and function of the knee joint. Our hypothesis is that the clinical outcomes between the AHPLT group and semitendinosus group are equivalent in controlling knee stability, and there is no serious donor site morbidity after harvesting the AHPLT.

Materials and Methods

This study obtained the informed consent of the patients and was approved by the local ethics committee. From March 2013 to March 2015, a prospective randomized clinical study was performed to compare the results of all-inside anatomical SB ACL reconstruction using the AHPLT and using semitendinosus tendons. Computer-generated randomization was done with inclusion criteria of primary ACL rupture in adult patients and exclusion criteria of serious osteoarthritis, revision cases, and multiple ligament injuries. Patients with chondral lesions greater than grade 2 and concomitant reparable meniscus tears were also excluded because of potential outcome impacts. One-hundred and twenty-four patients were randomized into two groups before the surgery: the AHPLT group ($n = 62$) and the semitendinosus group ($n = 62$). Preoperatively, physical examinations including the anterior drawer test and the pivot shift test were performed to judge the stability of the knee joint. All of the patients were evaluated with an International Knee Documentation Committee (IKDC) 2000 subjective score, a Visual Analogue Scale (VAS), and an American Orthopedic Foot and Ankle Score (AOFAS). A KT-1000 arthrometer was also used with knee flexion of 30° at 134 N. All of the tests were performed three times by another experienced orthopedic surgeon who was not involved in the surgery, and the mean of the three measurements was taken as the final value. All of the patients were educated beforehand. Similar knee incisions and ankle incisions were designed to make patients blind to the selection of the tendon harvest. Standard plain films and three-dimensional (3D) computed tomography (CT) were taken for all of the patients after surgery to evaluate the tunnel placement.[29–33] Instability alone and instability with pain were the two main symptoms. There were no demographic differences between the AHPLT group and the semitendinosus group (►Table 1). One young male in the AHPLT group had a continuously increasing C-reactive protein level at 3 days after the operation, but there was no infection after the administration of intravenous antibiotics. One male suffered an ACL group rerupture due to high-energy trauma at 27 months after surgery.

AHPLT Harvesting

We harvested the AHPLT by making a 2-cm skin incision over the posterior border of the lateral malleolus. A vessel clamp was used to separate the subcutaneous tissue from the retinacular tissue of the peroneal tendons. Using a zig-zag incision to expose the PLT, the graft was pulled up using an orthogonal clamp and then split longitudinally through the middle using a knife. The distal tendon of the anterior part was sutured. Then, using a knife to free the distal part of the PLT, a tendon stripper was used to harvest the tendon from the muscular part of the peroneus longus (►Fig. 1).

Semitendinosus Tendon Harvesting

Semitendinosus tendon harvesting was performed according the method described by Wittstein et al.[34] In this process, the

Table 1 Demographic data of the two groups

	Size (n)	Gender (M/F)	Age (y)	BMI (kg/cm^2)	Follow-up (mo)	Duration (mo)	Rerupture	Infection
AHPLT	62	34/28	29.1 ± 6.5	23.1 ± 2.0	29.7 ± 3.7	6.1 ± 6.5	0	1[a]
Semi	62	31/31	27.9 ± 6.7	22.6 ± 1.9	30.3 ± 3.5	5.7 ± 6.3	1	0

Abbreviations: AHPLT, anterior half of the peroneus longus tendon; BMI, body mass index; Semi, semitendinosus duration: time from injury to surgery.
Note: One female rerupture was caused by high-energy trauma. Continuous data are expressed as the mean ± standard deviation.
[a]Continuously increasing C-reactive protein.

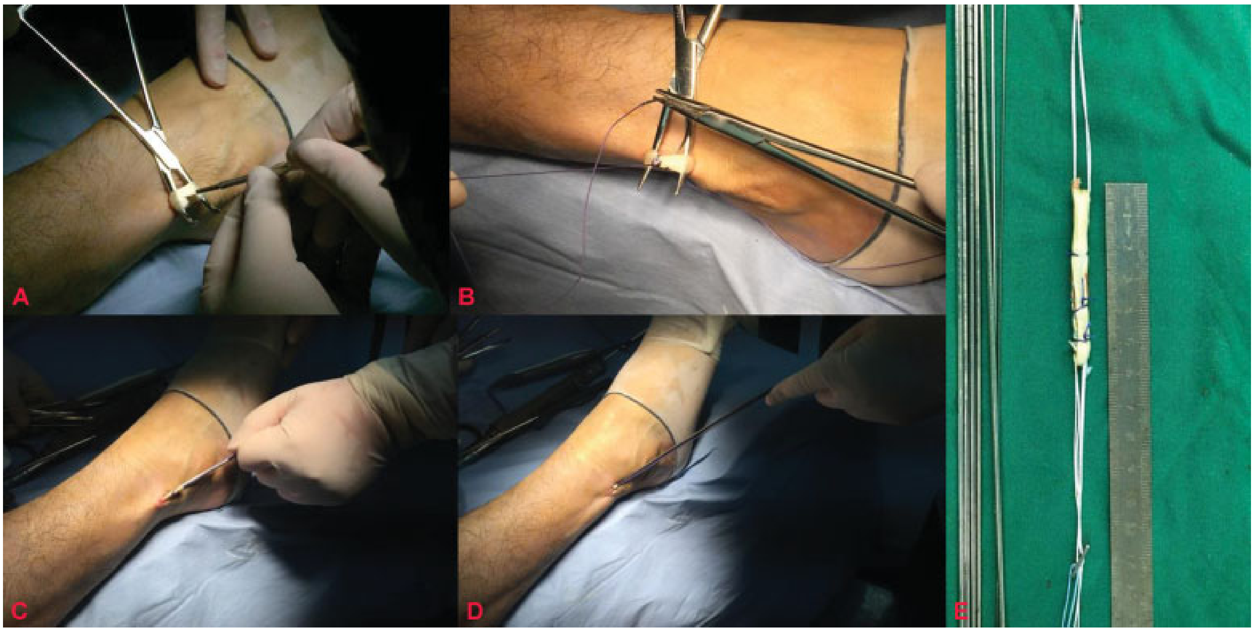

Fig. 1 Anterior half of peroneus longus tendon (PLT) harvesting. (**A**) A 2-cm skin incision over the posterior border of the lateral malleolus was used to expose the PLT. It was split longitudinally through the middle by knife. (**B**) The distal was weaved by suture. (**C** and **D**) Free the anterior part of the PLT and use tendon stripper to harvest the PLT. (**E**) Fold the half-PLT into four-strand autograft and measure the length and diameter.

identification of the semitendinosus and gracilis tendons is believed to be the key point. The semitendinosus tendon is flatter and inferior to the round, deep gracilis. All of the patients received similar knee incisions and ankle incisions to decrease the bias. The average diameter of the AHPLT graft was 8.0 ± 0.7 mm (7–10), while the semitendinosus graft was 8.1 ± 0.9 mm (7–10) (►**Table 2**).

Surgical Procedure

Anatomical and biomechanical studies have shown that the ACL consists of an anteromedial (AM) bundle and a posterolateral (PL) bundle.[4,35] Anatomical SB reconstruction is performed to restore the AM bundle. Different from standard anatomical ACL reconstruction techniques, the all-inside technique uses the RetroConstruction System (Arthrex, Naples, FL) to create tunnels with a retrograde drill. An autograft tunnel was drilled on the femur based on the identified ACL footprint sites through the accessory medial portal. The center of the tunnel was placed in the middle of the ACL anatomical insertion site but below the resident ridge. Tibial tunnel placement was based on the ACL tibial insertion site and the anterior horn of the lateral meniscus. The tibial tunnel was drilled with the tibial tunnel guide and created by the retrograde drill (Flipcutter, Arthrex); the center of this tunnel was closer to the medial intercondylar ridge. The Tightrope (Arthrex) was used to fix the grafts on both the femoral and tibial sites (►**Fig. 2**).

Table 2 Graft status

	Size (*n*)	Length (cm)	Diameter (mm)
AHPLT	62	6.4 ± 0.5	8.0 ± 0.7
Semi	62	6.5 ± 0.5	8.1 ± 0.9

Abbreviations: AHPLT, anterior half of the peroneus longus tendon; Semi, semitendinosus.

Rehabilitation

Ice compress was immediately used to decrease postoperative swelling and pain. The knee was kept in full extension in a brace for a couple of days. In weeks 0 to 3, all of the patients were encouraged to perform ankle pump exercises, isometric quadriceps contractions, and cycling training to improve the range of motion and knee stability. Full range of motion was obtained within 4 to 6 weeks. Full weight-bearing exercise was allowed by at least 4 weeks. Running was allowed after 3 months, but contact sports were not recommended until 9 months after the operation.

Measurement of the Tunnel Placement

X-ray imaging and 3D CT were used to evaluate the tunnel placement after reconstruction. Measurements of tunnel placements were performed using the digital radiography system (PACS, Siemens Healthcare, Forchheim, Germany) with the built-in digital rule. On the femoral side, a snapshot of the lateral femoral condyle at the medial-lateral view was obtained according the method described by Lertwanich.[30] CT scans (SOMATOM Definition AS + ; Siemens Healthcare) were performed to create a 3D model of each distal femur. In a distal view, the medial femoral condyle was virtually removed at the highest point of the anterior aperture of the intercondylar notch to create the view of the lateral femoral condyle. Then, the quadrant method described by Bernard et al[33] was used to measure the femoral tunnel on this snapshot of the lateral femoral condyle (►**Fig. 3**).

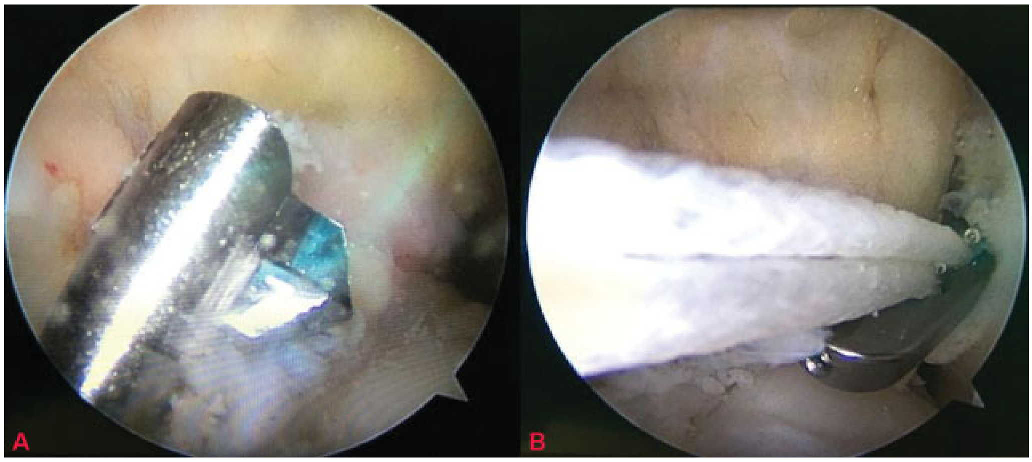

Fig. 2 All-inside anterior cruciate ligament (ACL) reconstruction. (**A**) Using retrograde drilling to a socket from inside-out. (**B**) Using the Tightrope to fix the graft.

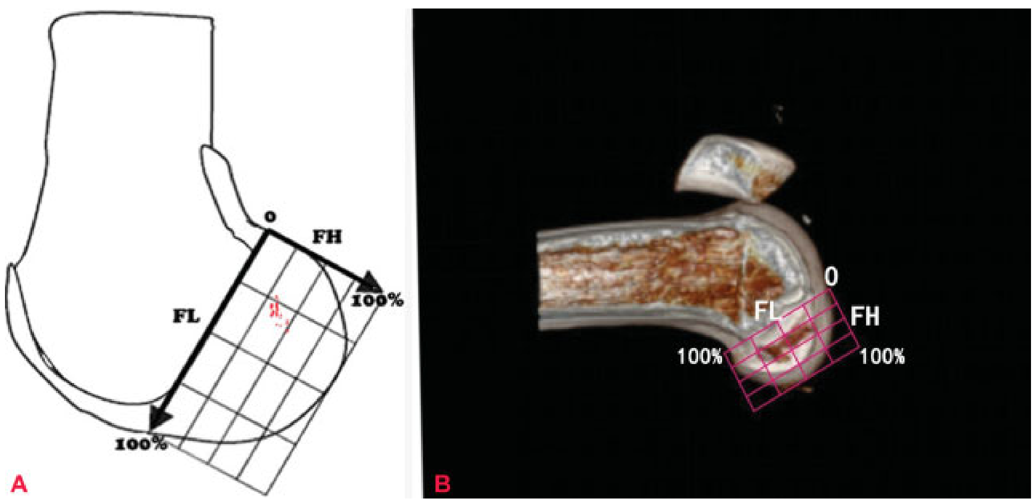

Fig. 3 (**A**) Femoral length (FL) represents the distance from the most posterior contour of the lateral femoral condyle parallel to the intercondylar notch roof and femoral height (FH) represents the perpendicular distance from the intercondylar notch roof to the deepest borders of the condyle. Femoral tunnel position on three-dimensional (3D) computed tomography (CT) is measured according the quadrant method. (**B**) Anatomic femoral tunnel placement. (Redrawn from Xu et al[42]).

The tibial tunnel position was mainly measured via X-ray imaging. The tibial plateau and the Amis and Jakob line[32] were taken as the referential marks to evaluate the tibial tunnel position (►**Fig. 4**). The tibial width was measured on the anteroposterior (AP) film representing the maximal distance of the tibial plateau from the most medial point to the most lateral point. All of the measurements were performed by one senior radiologist. Measurements were repeated at 3 months after the initial measurements to evaluate intraobserver reliability.

Outcome Evaluation

All of the patients were educated to come back for further consultation at 1, 3, 6, 12, and 24 months after the operation. At these time points, clinical outcomes were assessed, including range of motion; knee stability, which was evaluated with a KT-1000; anterior drawer test and pivot shift test; IKDC score; and VAS score. The conditions of the ankle donor site were also accounted for, and they were assessed by AOFAS score, pain, and muscle force.

Statistical Analysis

Descriptive data (mean, range, and standard deviation) were used in this study. The statistical analysis focused on the clinical outcomes over the study period. Differences between the AHPLT group and the semitendinosus group were assessed using an independent sample *t*-test for continuous variables. A probability value of $p < 0.05$ was considered to be statistically significant. SPSS software (version 17.0, SPSS, Inc., Chicago, IL) and Microsoft Excel (Microsoft, Redmond, WA) were used to analyze the data.

Before the study, the sample size was estimated on the basis of the hypothesis that the clinical scores between the control and the test group would not exceed 10%. For a *t*-test at $a = 0.05$ and to achieve 0.8 power, a sample size of at least 32 subjects was needed. Standard error and intraclass

Fig. 4 (A and B) Tibial tunnels with respect to the tibial plateau along the Amis and Jakob line(s) (Tibia%) are measured. Line P rests on the medial tibial plateau, while line S is parallel to P, passing through the posterior corner of the shelf (C). Tibial tunnel is placed at the site of anterior cruciate ligament (ACL) tibial footprint. (Redrawn from Xu et al[42]).

correlation coefficient of measurements were used to assess intraobserver reliability.

Results

All of the patients were followed up at 24 months after surgery. The average follow-up was 30.0 ± 3.6 (range, 24–35.9) months. There were no significant differences between the two groups in the stability of the knee and clinical scores (►**Tables 3** and **4**). One patient in the AHPLT group revealed a side-to-side difference of > 5 mm; however, the patient was satisfied with the outcomes. In the ankle donor site of the AHPLT group, the results showed no significant differences between the preoperative AOFAS score and the postoperative score (99.4 ± 1.14 vs. 99.1 ± 1.40), and the average AOFAS score of the AHPLT group was comparable to that of the semitendinosus group (99.1 ± 1.40 vs. 99.4 ± 1.27, $p > 0.05$). There was no serious instability, pain, and muscle force decline.

Tunnel Position

In the AHPLT group, the average center of the femoral tunnel was placed at 30.4 ± 4.2% of the femoral length and at 33.3 ± 5.0% of the femoral height. The center of the tibial tunnel was placed at 36.5 ± 5.4% of tibial plateau along the Amis and Jacob line. The tibial width was 43.1 ± 2.2%.

In the semitendinosus group, the average center of the femoral tunnel was placed at 29.6 ± 5.3% of the femoral length and 34.3 ± 3.9% of the femoral height. The center of the tibial tunnel was placed at 35.4 ± 4.4% of tibial plateau along the Amis and Jacob line. The tibial width was 44.2 ± 1.9%. Tunnel positions of all of the cases are shown in ►**Figs. 3** and **4**.

Intraobserver reliability was greater than 0.8 for all of the tunnel placement measurements, and the corresponding standard error of measurement ranged from 1.8 to 3.7%.

Table 3 Clinical outcomes of the AHPLT group and the semi group

	IKDC		VAS		KT-1000		Anterior	Draw	Test
	Pre-	Post-	Pre-	Post-	Pre-	Post-	+		–
AHPLT ($n = 62$)	52.6 ± 6.2	89.3 ± 8.4	2.89 ± 2.6	0.10 ± 0.30	5.06 ± 1.37	1.85 ± 0.77	43/62		59/62
Semi ($n = 62$)	51.2 ± 5.9	90.4 ± 7.1	2.38 ± 1.8	0.15 ± 0.35	4.66 ± 1.42	1.71 ± 0.57	51/62		60/62

Abbreviations: –, postoperative negative; +, preoperative positive; AHPLT, anterior half of the peroneus longus tendon; IKDC, International Knee Documentation Committee; Post-, postoperative; pre-, preoperative; Semi, semitendinosus; VAS, Visual Analogue Scale.

Table 4 Result of pivot shift of the two groups

	0		1		2		3	
	Pre-	Post-	Pre-	Post-	Pre-	Post-	Pre-	Post-
AHPLT ($n = 62$)	16	58	34	3	10	1	2	0
Semi ($n = 62$)	18	57	35	5	8	0	1	0

Abbreviations: AHPLT, anterior half of the peroneus longus tendon; Post-, postoperative; pre-, preoperative; Semi, semitendinosus.
Note: The value in the table means the positive amount of the rotatory instability of the involved knee.

Discussion

The most significant finding of this study was that all-inside anatomical SB reconstruction using the AHPLT showed good results in the clinical outcomes and in knee stability without any obvious ankle site complications.

Recently, researchers have become more interested in focusing on the anatomy of the ACL.[4,36–38] Anatomical studies of cadavers have shown that the ACL consists of two functional bundles: an AM bundle and a PL bundle. Although both bundles substantially contribute to the anterior and rotational stability of the knee, the biomechanical mechanism is a process of tension transition: during the process of knee extension to flexion, the tension transits from the PL bundle to the AM bundle. The PL bundle also tightens during knee rotation.[4,39–41] Anatomical ACL reconstruction has become more popular as it is thought to restore knee function more normally. Although SB or DB anatomical ACL reconstruction is still in debate,[2,3,42,43] it seems that DB anatomical ACL reconstruction has had better results in anterior laxity and the pivot test.[2,43–45] For example, in Aglietti et al's randomized controlled study,[43] patients in the DB group showed better VAS, objective IKDC scores, and knee laxity than in the SB group in the 2-year minimum follow-up. Kondo et al performed a prospective study of 328 patients[2] to compare the results of DB and SB anatomical reconstruction. The results showed that the DB reconstruction had better results in controlling the knee anterior and rotation stability. Similar results have been reported by Yasuda et al[3] and Hussein et al.[46] Hussein et al performed a study to compare the results of DB anatomical reconstruction, SB anatomical reconstruction, and conventional SB reconstruction. The outcomes showed excellent results of the DB anatomical reconstruction, which was significantly superior to the conventional SB reconstruction and better than the SB anatomical reconstruction. However, some studies also reported that there were no significant results between the DB anatomical group and the SB anatomical group. Xu et al[42] performed a randomized clinical study of 80 cases comparing the results of DB anatomical reconstruction and SB anatomical reconstruction. They found both groups can restore the knee's stability and functions very well; DB anatomical reconstruction did not show any advantages over SB anatomical reconstruction. In a comparative study of 113 patients, Park et al[47] found that there were no differences between the DB reconstruction group and the SB group in knee stability results and in terms of patient satisfaction. Tunnel position locations in anatomical ACL insertion sites were believed to be the key points of excellent results of ACL anatomical reconstruction.[31,42,48,49] Malposition of the tunnel placement was considered to be the main technical failure in ACL reconstruction. Based on the development of radiography techniques and anatomical studies, 3D CT scans were widely used to assess the tunnel position after ACL reconstruction.[29–31,49] These techniques can generate a stereo perspective of bony morphology and tunnel aperture, which makes tunnel evaluation more reliable and precise, especially for measuring the femoral tunnel with the quadrant method. Lertwanich et al[30] performed a 3D reconstructed CT measuring study of 31 cadavers to evaluate the reliability of the ACL tunnel location measurement by using three methods of 3D reconstructed CT. The results showed high intraobserver and interobserver reliability of the femoral and tibial tunnel location measurements with more than 0.95 intraclass correlation coefficients (ICCs). The correct tunnel location was essential for optimum clinical results in anatomical reconstruction. In SB anatomical reconstruction, the optimal placement of the tunnel position has been evaluated.[29,42] On the femoral side, the center of the tunnel was optimally located at 24 to 27% from the proximal condylar surface (parallel to the Blumensaat line), at 28 to 34% from the notch roof (perpendicular to the Blumensaat line).[29,50] On the tibial tunnel, the optimal anterior-posterior placement of the bone tunnel was proposed around 43%, ranging from 27 to 60% according to the Amis and Jakob line.[29,42] In our study, on average, the femoral tunnel's center was placed at 30.0% from the femoral length and at 33.8% from the femoral height. The anterior-posterior placement of the tibial tunnel was placed at 36.0% along the Amis and Jacob line, which was quiet consistent with other studies of anatomical reconstruction. Excellent outcomes of ACL reconstruction were the main standard to judge the success of the operation. All of the patients in this study had restored knee stability and kinematics with no dysfunction or graft impingement during the 2 years of follow-up. We thought our tunnel positions were within the ACL original insertion sites.

Hamstring tendons, patellar tendons, and quadriceps tendons have been widely used in knee ligament reconstruction.[10,44,46,51–53] The hamstring tendons that are harvested on the same leg are the primary choice for cruciate ligament reconstruction. Generally, they are sufficient for SB cruciate ligament reconstruction; however, in clinical practice, shortages in supplies of harvested hamstring tendons are sometimes encountered. Although, some studies have demonstrated that the size of the hamstring tendon can be predicted by anthropometric measurements,[13,14] there are obvious individual differences and a lack of experience or technique problems during harvesting meaning that the hamstring grafts are usually too thin or too short to reach the adequate diameter and length for cruciate ligament reconstruction, especially for DB ACL and PCL reconstruction or for mutilligament reconstruction. In the cases of ACL rupture combined with knee collateral ligament rupture, an additional autograft is needed. In addition, in some conditions of simultaneous SB ACL and PCL reconstructions, the semitendinosus tendon is sufficient to produce an optimal four-stranded graft for ACL reconstruction; however, the gracilis tendon alone is not strong enough for the PCL reconstruction. Also, in this condition, a supplement of other tendon grafts is needed for augmentation. Although, in theory, quadricep tendons or patellar tendons can be harvested as an additional or alterative graft, in clinical practice, we seldom chose them as optimal donor sites considering the potential morbidities of extension mechanism or complications after harvesting.[52,54] Allografts may have been a good choice over the past few decades,[55,56] but it is limited in use due to the possible immunological rejection,[57,58] scarcity of resources, or relevant ethical issues. From our perspective, the PLT may be an ideal alternative for cruciate ligament reconstructive procedures as it can be easily and safely harvested. First, because of the superficial location, the PLT can be easily and quickly exposed rather than the hamstring tendons. Moreover, unlike the complicated anatomical structure of the semitendinosus and gracilis tendon,[34] there are no other tendons nearby or fiber connections, deep fascia between the PLT, which makes the harvesting procedure go more smoothly. Another reason is that the PLT or the AHPLT graft has good biomechanical properties. In Zhao and Huangfus' study,[19] the results showed that the failure load of the AHPLT was similar to that of the semitendinosus tendon and significant superior than that of the gracilis tendon. In addition, the usable length of the AHPLT is acceptable for reconstruction compared with that of the semitendinosus tendon and gracilis tendon. While PLT may present suitable properties for use in ligament reconstruction, possible donor site morbidity after harvesting should be a serious concern.[20] The peroneus longus muscle plays an important part in the functions of eversion of the foot, plantar of the ankle, and steadying the transreverse arch.[23–26] Total removal of the PLT would interfere with the ankle stabilizing structure, resulting in the impairment of the ankle or foot function. In Angthong et al's clinical study of 24 cases,[20] the results showed that the ankle stability and function were significantly lower on the involved site compared with the contralateral site. However, Kerimoğlu et al[17] reported that there was no obvious ankle joint dysfunction after harvesting the PLT. While the sample size and the follow-up time of Angthong et al's study were not enough to draw a precise conclusion of ankle function loss, it helps to indicate the concerns to surgeons before total removal of the PLT as a graft. Thus, we are reluctant to harvest the total tendon before more biomechanical and clinical studies are performed to justify the safety of this procedure. Although, the AHPLT was not widely used in the clinic, the safety and efficacy have been verified by some authors. However, as we know, there are only three reports regarding the use of AHPLT in ligament reconstruction, including medial patellofemoral ligament reconstruction, ACL augmentation, and ankle ligament reconstruction. Zhao and Huangfu,[19] in their clinical study of 92 patients, reported that there were no significant differences between the preoperative AOFAS scores and postoperative scores of the ankle donor site; there were also no differences in the Foot and Ankle Disability Index (FADI) scores (►**Table 5**). There were no signs of peroneus nerve injury, PLT rupture, or tendinopathy in 2 years of follow-up. Liu et al[18] showed that patients using half-PLT graft augmentation of ACL reconstruction had excellent knee stability, good IKDC scores, and good Lysholm scores at 3 years after the operation. The average postoperative FADI score was 135.8. No pain, muscle power decrease of foot flexion, and eversion of the ankle donor site were found. Park[16] did a case series study of anatomical lateral ligament reconstruction using the AHPLT to evaluate the donor site morbidity; their results demonstrated that clinical results, including VAS score, AOFAS, and Karlsson–Peterson scores and radiographic results, such as talar tilt angle and anterior talar displacement, significantly improved from the preoperation. No significant differences were observed between the uninvolved and involved legs in the mean peak torque for plantar flexion at angular speeds of 30 and 120 deg/s or for eversion at angular speeds of 30 and 60 deg/s. In our prospective randomized comparative study of 124 patients, the results of the AHPLT group showed that the preoperative and postoperative AOFAS scores were 99.4 ± 1.14 and 99.1 ± 1.40, respectively. A comparison was essential for the study's reliability, which makes a conclusion more accurate. Different from the studies presented above, in our study, there were comparisons among patients who did not undergo PLT harvesting, those who underwent the anterior half harvesting. Although the mean

Table 5 Comparing the result of the current studies

Author	Graft	Technique	IKDC		VAS		KT-1000/2000 (side-to-side)		AOFAS/FADI	
			Pre-	Post-	Pre-	Post-	Pre-	Post-	Pre-	Post-
Present study	AHPLT	All-inside	52.6	89.3 (8.4)	2.89	0.10	5.06	1.85	99.4	99.1
	Semi	All-inside	51.2	90.4 (7.1)	2.38	0.15	4.66	1.71	99.5	99.4
Schurz et al	Semi	All-inside	44.6	89.7 (7.3)	5.00	0.14	–	1.70	–	–
Lubowitz	Allograft	All-inside	47.4	86.5 (11.6)	2.60	–2.50	–	–	–	–
Benea et al	Semi	All-inside	60.6	81.3 (14.4)	–	0.19	4.2	1.2	–	–
Zhao	AHPLT	–	–	–	–	–	–	–	97.4	97.2
Liu et al	1/2 PLT	Augmentation	–	86	–	–	–	1.28	136	135.8
Angthong et al	PLT	–	–	–	–	–	–	–	100	96

Abbreviations: AOFAS, American Orthopedic Foot and Ankle Score; AHPLT, anterior half of the peroneus longus tendon; FADI, Foot and Ankle Disability Index; IKDC, International Knee Documentation Committee; PLT, peroneus longus tendon; Semi, semitendinosus; –, did not mention in the article or no meaning to compare; VAS, Visual Analogue Scale.
Note: Values in parenthesis are standard deviation.

AOFAS score of the semitendinosus group was higher than the score of the AHPLT group, it did not show a significant difference (99.4 $\pm$ 1.27 vs. 99.1 $\pm$ 1.40, $p > 0.05$). No pain, instability, or any discomfort over the donor site of the ankle was found in both groups in the 2 years of follow-up.

The other main advantage of this study was that we evaluated the clinical outcomes of the AHPLT graft by using the all-inside technique. This technique has been used in clinical practice for several years, and it offers the advantages of decreased bone removal, less postoperative pain, and less need for tendons.[10–12,27,28] Considering the good functional results and possible inadequate length and diameter of a four-stranded autograft for classical reconstruction, the all-inside technique is considered to be a good choice in study design. Schurz et al[10] performed a study using the semitendinosus tendon to evaluate the clinical and functional outcomes of all-inside anatomical ACL reconstruction with a minimum follow-up of 24 months, and they found significant improvement of the IKDC score, VAS score, and Tegner score between the baseline and the final clinical follow-up. Lubowitz,[28] in their prospective comparative study between the all-inside technique and a full tibial tunnel technique, found a good IKDC score and lower pain score in the all-inside group at 2 years of follow-up. Furthermore, Benea et al[12] recently published the results of pain evaluation in a randomized comparative parallel trial comparing the all-inside technique with classical surgery and found that the pain level was lower in the all-inside group than in the classical group at 1 month after surgery (3.2 $\pm$ 5.5 vs. 8.6 $\pm$ 10). In our study, the results showed no significant difference between the semitendinosus group and the AHPLT group in IKDC score, VAS score, and KT-1000 measurements, which was comparable to the results of current study (►**Tables 3** and **5**).

There were some limitations in this study. The main weakness of this study was that we used the anterior drawer test and pivot shift test as methods to evaluate the anterior translation and rotational stability. Although no difference was revealed, we considered these physical examinations to be subjective tests, which are prone to interexaminer variation. A more objective clinical test needs to be used to reflect the true functions of the knee. In addition, quantitative date from the peak isokinetic torques for ankle plamter flexion and eversion should be applied to assess the ankle site condition.

Conclusion

There was no significant difference in knee stability or clinical functional outcomes between the semitendinosus group and the AHPLT group at 2 years of follow-up. The AHPLT graft may be a good alternative for all-inside ACL reconstruction, with no significant donor site complications.

Ethical Approval

All of the procedures involving human participants in this study were performed in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards.

Conflict of Interest

None.

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