Autograft Versus Allograft for Posterior Cruciate Ligament Reconstruction

An Updated Systematic Review and Meta-analysis

John W. Belk,* Matthew J. Kraeutler,*† MD, Justin M. Purcell,* BA, and Eric C. McCarty,* MD
Investigation performed at CU Sports Medicine and Performance Center, University of Colorado School of Medicine, Department of Orthopedics, Boulder, Colorado, USA

Background: Multiple studies have demonstrated a higher risk of graft failure after anterior cruciate ligament reconstruction with allograft, but limited data are available comparing outcomes of posterior cruciate ligament reconstruction (PCLR) with autograft versus allograft.

Purpose: To compare the clinical outcomes of autograft versus allograft for primary PCLR.

Study Design: Systematic review.

Methods: A systematic review was performed by searching PubMed, the Cochrane Library, and EMBASE to locate studies (level of evidence I-III) comparing clinical outcomes of autograft versus allograft in patients undergoing primary PCLR with the conventional transtibial technique. Search terms used were ''posterior cruciate ligament,'' ''autograft,'' and ''allograft.'' Patients were evaluated based on graft failure rate, examination of knee laxity, and patient-reported outcome scores (Lysholm, Tegner, subjective International Knee Documentation Committee [IKDC], and objective IKDC scores).

Results: Five studies (2 level II, 3 level III) were identified that met inclusion criteria, including a total of 132 patients undergoing PCLR with autograft (semitendinosus-gracilis or bone–patellar tendon–bone) and 110 patients with allograft (tibialis anterior, Achilles tendon, or bone–patellar tendon–bone). No patients experienced graft failure. Average anteroposterior (AP) knee laxity was significantly higher in allograft patients (3.8 mm) compared with autograft patients (3.1 mm) ($P < .01$). Subjective IKDC, Lysholm, and Tegner scores improved for both groups across studies, without a significant difference in improvement between groups except in one study, in which Lysholm scores improved to a significantly greater extent in the autograft group ($P < .01$).

Conclusion: Patients undergoing primary PCLR with either autograft or allograft can be expected to experience improvement in clinical outcomes. Autograft patients experienced less AP knee laxity postoperatively, although the clinical significance of this is unclear and subjective outcomes improved substantially and to a similar degree in both groups.

Keywords: posterior cruciate ligament reconstruction; autograft; allograft

The posterior cruciate ligament (PCL) originates on the medial femoral condyle and inserts on the posterior intercondylar area of the tibia. The PCL acts to resist posterior tibial translation and is most commonly injured during motor vehicle accidents in which a posterior force is directed against the tibia.[12,26] A fall on a flexed knee is another common mechanism of PCL injury.[9] Injury to the PCL occurs in about 3% of all knee injuries[4] and occurs most commonly in association with a combined disruption of the anterior cruciate ligament (ACL), posterolateral corner, and periarticular fractures of the knee.[21]

Several studies have compared the clinical outcomes of ACL reconstruction (ACLR) with autograft versus allograft, and while many of these studies[10,14,20] have demonstrated improved clinical outcomes in patients with autograft, other studies[15,23,28] have found no significant differences in outcomes between autograft and nonirradiated allograft. However, much less is known regarding autograft versus allograft for PCL reconstruction (PCLR). A systematic review from 2013[6] found that the data on autograft versus allograft use for PCLR are scarce, but given the limited data, no significant differences in clinical outcomes could be established. Several studies[16,17,24] have been published since that review comparing autograft

†Address correspondence to Matthew J. Kraeutler, MD, CU Sports Medicine and Performance Center, 2150 Stadium Drive, 2nd Floor, Boulder, CO 80309, USA (email: matthew.kraeutler@ucdenver.edu).

*Department of Orthopedics, University of Colorado School of Medicine, Aurora, Colorado, USA.

One or more of the authors has declared the following potential conflict of interest or source of funding: E.C.M. receives IP royalties from and is a paid consultant for Biomet and receives research support from Biomet, Mitek, Smith & Nephew, and Stryker.

The American Journal of Sports Medicine, Vol. XX, No. X
DOI: 10.1177/0363546517713164

TABLE 1
Studies Included[a]

Study	Level of Evidence	No. of Patients (Autograft/Allograft)	Autograft Type	Allograft Type
Li et al (2016)[17]	II	53 (26/27)	S/G	Tibialis anterior
Li et al (2015)[16]	III	37 (18/19)	S/G	Tibialis anterior
Sun et al (2015)[24]	III	71 (36/35)	S/G	NR
Ahn et al (2005)[1]	III	36 (18/18)	S/G	Achilles
Kim et al (2000)[13]	II	45 (34/11)	BPTB	BPTB

[a]BPTB, bone–patellar tendon–bone; NR, not reported; S/G, semitendinosus-gracilis.

versus allograft use for PCLR. The purpose of this study is to provide an updated systematic review of the literature comparing the clinical outcomes of PCLR with autograft versus allograft. The authors hypothesized that there would be no significant differences in clinical outcomes between the two groups.

METHODS

A systematic review of multiple databases was performed. Two independent reviewers searched PubMed, EMBASE, and the Cochrane Library up to December 1, 2016. The following search phrase was used: "posterior cruciate ligament" AND autograft AND allograft. A total of 111 studies were reviewed by title and/or abstract to determine study relevance based on inclusion and exclusion criteria. Inclusion criteria included studies that directly compared the clinical outcomes of autograft and allograft for PCLR (level of evidence I-III) with the conventional transtibial technique. Patients undergoing PCLR via the inlay technique were excluded. In addition, studies were excluded if they were nonclinical studies, noncomparative studies, studies focused on other ligament reconstruction, and studies unrelated to the knee. Any discrepancies were resolved by a third reviewer.

Statistical Analysis

A weighted average was calculated for numerical demographics (age and the interval from injury to operation). A meta-analysis of patient-reported outcome scores was not possible as some studies did not report standard deviations and the authors of these studies could not be reached for this information. A chi-square test was used to compare objective International Knee Documentation Committee (IKDC)[5] results of autograft versus allograft patients. For anteroposterior (AP) laxity measurements, a weighted average and composite standard deviation were calculated for each group, as previously described.[14] Data were then analyzed by use of a 2-sample independent t test, based on unequal variance (www.openepi.com). In addition, a difference in the means with 95% confidence intervals for AP laxity was calculated for each study and as an overall total to compare autograft versus allograft (https://graphpad.com/quickcalcs/ErrorProp1.cfm). A subanalysis was performed to compare outcomes of tibialis anterior versus Achilles tendon allografts by use of the same methods.

RESULTS

Five studies met inclusion and exclusion criteria (Figure 1); the studies included 132 patients undergoing PCLR with autograft and 110 with allograft. The mean patient age at the time of surgery was 31.6 years for autograft patients (range, 16-58 years) and 31.9 years for allograft patients (range, 17-60 years). The mean interval between time of injury and time of operation was 6.9 months for autograft patients (range, 3 weeks to 12 months) and 6.6 months for allograft patients (range, 3 weeks to 12 months). The mean follow-up time was 3.5 years for autograft patients (range, 2-6 years) and 3.4 years for allograft patients (range, 2-6 years). The most commonly used autograft was hamstring (semitendinosus-gracilis), while the most commonly used allograft was tibialis anterior (Table 1). One study[13] included a group of 10 patients undergoing the inlay technique for PCLR, and these patients were excluded from this review.

Graft Selection

Li et al[17] randomized patients to autograft or allograft. Two studies[16,24] selected graft type based on patient preference. Kim et al[13] performed PCLR with a bone–patellar tendon–bone (BPTB) autograft except in cases of patellofemoral joint disease, patellofemoral maltracking, narrow width of the patellar tendon (<30 mm wide), or poor skin condition. In these cases, a BPTB allograft was used. Ahn et al[1] did not describe how patients were allocated to autograft or allograft.

Clinical Comparisons

Li et al[17] found no significant differences between autograft and allograft groups with regard to age, sex distribution, body mass index (BMI), duration from injury to

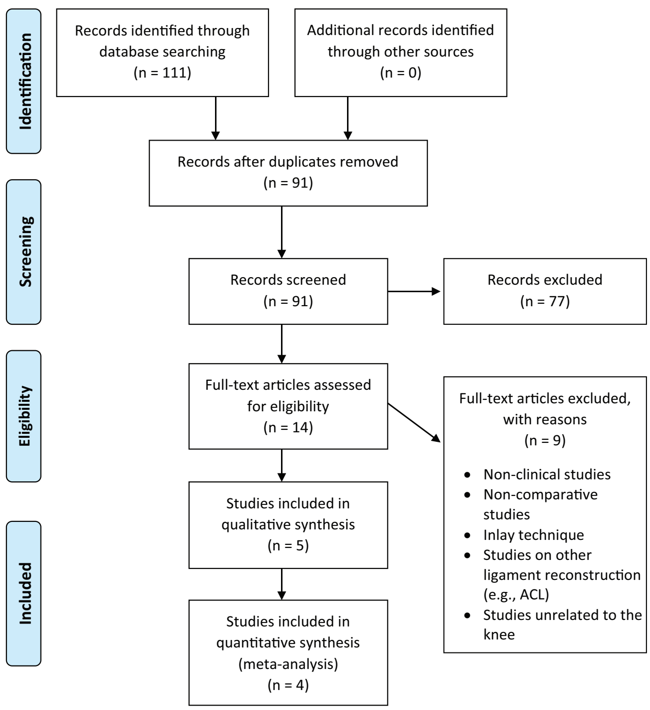

Figure 1. PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) flow diagram. ACL, anterior cruciate ligament.

surgery, type of injury, and follow-up duration. Li et al[16] found no significant differences between groups with regard to age at surgery, BMI, or duration from injury to surgery. Sun et al[24] found no differences between groups with regard to sex, age, duration of injury (acute vs chronic), or the proportion of patients with an intraoperative finding of a meniscal injury, cartilage lesion, or medial collateral ligament (MCL) injury. Ahn et al[1] found no differences between groups with regard to age, sex, activity level, or duration from injury to surgery. Kim et al[13] did not compare demographics between autograft and allograft patients.

Attrition Rates

Li et al[17] randomized a total of 90 patients to autograft, hybrid graft, or gamma-irradiated allograft, with 30 patients in each group. At final follow-up, 26 autograft patients (26/30, 87%) and 27 allograft patients (27/30, 90%) were evaluated. Sun et al[24] evaluated 100% of included patients at final follow-up. Ahn et al[1] fully evaluated 36 of 41 eligible patients (88%) in their retrospective cohort study. The remaining 5 patients had moved since surgery, but all were reached by telephone and subjectively graded their knee as "normal" or "nearly normal." Two studies[13,16] did not specify the follow-up rates of all included patients.

Surgical Technique

All 5 studies[1,13,16,17,24] performed PCLR in similar fashions. PCLR was performed arthroscopically in all cases, with femoral tunnel drilling done through the anteromedial portal by use of either an inside-out or an outside-in technique. Femoral fixation was performed with either an absorbable screw or an EndoButton in all studies. One study[17] included patients undergoing concomitant meniscal repair or partial meniscectomy. No patients in any of the included studies underwent concomitant ACL or collateral ligament reconstruction. All 242 patients were treated with the conventional transtibial technique. Autograft and allograft sources varied between studies (Table 1). In 2 studies,[16,17] all allografts were treated with washing, radiation sterilization, and deep-freezing techniques to decrease immunogenicity and increase histocompatibility. Three studies[16,17,24] described sterilizing the allogenic tendon with gamma irradiation at a dose of 2.5 Mrad.

TABLE 2
AP Laxity[a]

Study	Autograft AP Laxity, mm	Allograft AP Laxity, mm	*P* Value
Li et al (2016)[17]	2.1 ± 1.0	3.5 ± 1.1	<.001
Li et al (2015)[16]	4.1 ± 1.7	3.3 ± 1.8	ns
Sun et al (2015)[24]	3.8 ± 1.5	4.8 ± 1.7	.03
Ahn et al (2005)[1]	2.2 ± 1.8	2.9 ± 1.9	.14
Kim et al (2000)[13]	NR	NR	ns
Total	3.1 ± 1.5	3.8 ± 1.6	<.01

[a]Laxity is reported as mean ± standard deviation, with the "Total" row reported as a weighted mean ± composite standard deviation. AP, anteroposterior; NR, not reported; ns, nonsignificant.

Treatment Failures

Three studies[1,16,17] reported graft failures, of which there were none in either autograft or allograft groups.

AP Laxity

All 5 studies described using either a KT-1000 or KT-2000 arthrometer to measure posterior laxity of the affected knee. The side-to-side difference in posterior laxity was measured with the affected knee positioned in 90° of flexion. The weighted average side-to-side difference in AP laxity among all studies was significantly greater in allograft patients (3.8 mm vs 3.1 mm) (Table 2, Figure 2). Two individual studies[17,24] found significantly greater laxity in allograft patients.

Among the 2 studies[16,17] that used a tibialis anterior allograft, the weighted average side-to-side difference in AP laxity was 3.4 ± 1.4 mm, which was not significantly different from that reported for Achilles tendon allografts by Ahn et al[1] (P = .31).

Objective IKDC

Two studies[1,16] reported results of the objective IKDC score. Among these 2 studies, no difference was found between groups (P = .67) (Table 3). In addition, no difference was found in the proportion of objective IKDC scores

TABLE 3
Objective IKDC Scores[a]

Study	Normal		Nearly Normal		Abnormal		Severely Abnormal	
	Auto	Allo	Auto	Allo	Auto	Allo	Auto	Allo
Li et al (2015)[16]	5	6	9	8	3	4	1	1
Ahn et al (2005)[1]	7	2	9	12	2	3	0	1
Total	12	8	18	20	5	7	1	2

[a]No significant difference was found in total distribution of scores between autograft (Auto) and allograft (Allo) groups. IKDC, International Knee Documentation Committee.

TABLE 4
Patient-Reported Outcomes[a]

Study	Subjective IKDC		Lysholm		Tegner	
	Autograft	Allograft	Autograft	Allograft	Autograft	Allograft
Li et al (2016)[17]	17.0 (66.5-83.5)	14.3 (65.9-80.2)	20.0 (64.0-84.0)	21.1 (64.1-85.2)	4.0 (2.0-6.0)	4.0 (2.0-6.0)
Li et al (2015)[16]	NR	NR	24.0 (63.8-87.8)	21.1 (64.1-85.2)	4.1 (2.7-6.8)	3.6 (2.6-6.2)
Sun et al (2015)[24]	22.1 (58.9-81.0)	22.3 (57.7-80.0)	24.5 (57.5-82.0)	27.7 (56.3-84.0)	3.8 (3.9-7.7)	3.4 (3.7-7.1)
Ahn et al (2005)[1]	NR	NR	21.9[b] (68.2-90.1)	17.2[b] (68.6-85.8)	NR	NR
Kim et al (2000)[13]	NR	NR	NR	NR	NR	NR
Total	20.0	18.8	22.7	22.7	3.9	3.7

[a]Scores are reported as a mean score of improvement from preoperative to postoperative assessments (mean preoperative score to mean postoperative score), with the "Total" row reported as a weighted mean improvement score. IKDC, International Knee Documentation Committee; NR, not reported.
[b]$P < .01$.

between the allograft types (tibialis anterior and Achilles tendon) used in these studies (P = .40).

Patient-Reported Outcomes

Two studies[17,24] used the Lysholm,[18] Tegner,[25] and subjective IKDC[7] scores, while one study[16] used the Lysholm and Tegner scores. Ahn et al[1] used the Lysholm score. One study[13] used both Lysholm and Tegner scores but compared scores between patients undergoing the conventional 1-incision technique versus the 2-incision inlay technique rather than between autograft versus allograft groups. Patient-reported outcomes (PROs) are shown in Table 4. Only one study[1] reported a significant difference in outcome scores between the 2 groups, in which autograft patients had significantly greater improvement in Lysholm scores than allograft patients.

DISCUSSION

The results of this systematic review suggest that patients undergoing primary PCLR experience less postoperative AP knee laxity with an autograft versus an allograft. However, the clinical significance of this is unclear. Other than one study[1] that reported a significantly greater improvement

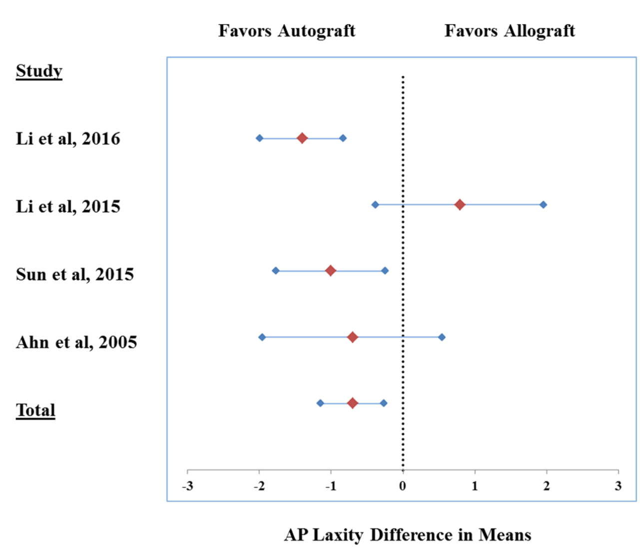

Figure 2. Forest plot representing the difference in the means of anteroposterior (AP) laxity measurements between autograft and allograft patients. Bars represent 95% confidence intervals.

in Lysholm score in autograft patients, no significant differences were found between groups in any study with regard to PROs or objective IKDC scores.

Several studies have compared outcomes of autograft versus allograft for primary ACLR, with some studies demonstrating better outcomes with autograft, especially in young, active patients.[10,14,20] These superior outcomes include lower rates of graft rupture, lower levels of AP knee laxity, and higher PROs (Lysholm, Tegner, subjective IKDC). In addition, autografts have the benefit of earlier incorporation and no rejection or disease transmission.[8] However, the inferior results of allografts may be due to gamma irradiation, as other studies[15,23,28] have demonstrated no significant differences in clinical outcomes after ACLR with autograft versus nonirradiated allograft.

Although the authors did find some improved outcomes after PCLR with autograft, the results of this systematic review are not as convincing as the results that have been demonstrated after ACLR. It was found that AP knee laxity was significantly higher ($P < .01$) in patients with an allograft, although no significant differences were found in PROs except in one study[1] in which autograft patients had a significantly greater improvement in Lysholm score than allograft patients. The authors believe this may be due to a few potential reasons, one of which is that the PCL is not ruptured nearly as often as other ligaments in the knee such as the ACL. In addition, when the PCL is ruptured and surgical reconstruction is performed, revisions are extremely rare. Wang et al[27] found there were 701 PCLRs in the United States per year from 2007 to 2011, in comparison with 120,000 ACL injuries annually in the United States.[11] Additionally, the revision rate after ACLR is much higher (between 5% and 15%)[2] than after PCLR (0% in this review). Because revision PCLR is so rare, the graft type used for this procedure may not play as significant a role in determining patient outcomes as it does with ACLR. Even though KT-1000 arthrometer results showed significantly less AP stability with allograft, this is an objective test and does not take into account subjective instability that patients experience during walking or other activities. Therefore, the clinical significance of these findings is unknown. However, one potential cause of greater AP laxity in allograft patients may be the lack of graft incorporation.[19] One risk of allografts is decreased biological incorporation of the graft, which can result in greater AP laxity in the affected knee as the graft is less firmly fixed in the bone tunnel. During ACLR, immunological reactions between allograft and bone tunnels may occur, thereby causing tunnel widening and graft laxity.[3,22] It is possible that this process occurs similarly after PCLR with allograft.

The strengths of this study include a comprehensive systematic review performed by 2 independent reviewers. This is also the first systematic review since 2013 on autograft versus allograft for PCLR, with 3 additional comparative studies and 151 additional patients from comparative studies since the last systematic review on the same topic. The limitations of this study should also be noted. In particular, only 5 studies were included in this systematic review, none of which were Level I evidence. In addition, the studies included used a variety of autograft and allograft types. Finally, some of these studies did not provide standard deviations for various PROs, thereby prohibiting the authors from performing a meta-analysis on these outcomes.

CONCLUSION

Patients undergoing primary PCLR with either autograft or allograft can be expected to experience improvement in clinical outcomes. Autograft patients experienced less AP knee laxity postoperatively, although the clinical significance of this is unclear and subjective outcomes improved substantially and to a similar degree in both groups.

REFERENCES

1. Ahn JH, Yoo JC, Wang JH. Posterior cruciate ligament reconstruction: double-loop hamstring tendon autograft versus Achilles tendon allograft—clinical results of a minimum 2-year follow-up. *Arthroscopy*. 2005;21(8):965-969.
2. Bach BR. Revision anterior cruciate ligament surgery. *Arthroscopy*. 2003;19(suppl 1):14-29.
3. Chen CH. Graft healing in anterior cruciate ligament reconstruction. *Sports Med Arthrosc Rehabil Ther Technol*. 2009;1(1):21.
4. Fanelli GC, Beck JD, Edson CJ. Double bundle posterior cruciate ligament reconstruction: surgical technique and results. *Sports Med Arthrosc*. 2010;18(4):242-248.
5. Hefti F, Müller W, Jakob RP, Staubli HU. Evaluation of knee ligament injuries with the IKDC form. *Knee Surg Sports Traumatol Arthrosc*. 1993;1(3-4):226-234.
6. Hudgens JL, Gillette BP, Krych AJ, Stuart MJ, May JH, Levy BA. Allograft versus autograft in posterior cruciate ligament reconstruction: an evidence-based systematic review. *J Knee Surg*. 2013;26(2):109-115.
7. Irrgang JJ, Anderson AF, Boland AL, et al. Development and validation of the International Knee Documentation Committee subjective knee form. *Am J Sports Med*. 2001;29(5):600-613.
8. Jost PW, Dy CJ, Robertson CM, Kelly AM. Allograft use in anterior cruciate ligament reconstruction. *HSS J*. 2011;7(3):251-256.
9. Jung YB, Lee YS. Current trend of treatment of PCL and PL corner injury. *J Korean Arthrosc Soc*. 2005;9:1-8.
10. Kaeding CC, Aros B, Pedroza A, et al. Allograft versus autograft anterior cruciate ligament reconstruction: predictors of failure from a MOON prospective longitudinal cohort. *Sports Health*. 2011;3(1):73-81.
11. Kaeding CC, Léger-St-Jean B, Magnussen RA. Epidemiology and diagnosis of anterior cruciate ligament injuries. *Clin Sports Med*. 2017;36(1):1-8.
12. Kannus P, Bergfeld J, Jarvinen M, et al. Injuries to the posterior cruciate ligament of the knee. *Sports Med*. 1991;12(2):110-131.
13. Kim SJ, Shin SJ, Kim HK, Jahng JS, Kim HS. Comparison of 1- and 2-incision posterior cruciate ligament reconstructions. *Arthroscopy*. 2000;16(3):268-278.
14. Kraeutler MJ, Bravman JT, McCarty EC. Bone-patellar tendon-bone autograft versus allograft in outcomes of anterior cruciate ligament reconstruction: a meta-analysis of 5182 patients. *Am J Sports Med*. 2013;41(10):2439-2448.
15. Lamblin CJ, Waterman BR, Lubowitz JH. Anterior cruciate ligament reconstruction with autografts compared with non-irradiated, non-chemically treated allografts. *Arthroscopy*. 2013;29(6):1113-1122.
16. Li B, Wang JS, He M, et al. Comparison of hamstring tendon autograft and tibialis anterior allograft in arthroscopic transtibial single-bundle posterior cruciate ligament reconstruction. *Knee Surg Sports Traumatol Arthrosc*. 2015;23(10):3077-3084.
17. Li J, Kong F, Gao X, Shen Y, Gao S. Prospective randomized comparison of knee stability and proprioception for posterior cruciate ligament reconstruction with autograft, hybrid graft, and γ-irradiated allograft. *Arthroscopy*. 2016;32(12):2548-2555.

18. Lysholm J, Gillquist J. Evaluation of knee ligament surgery results with special emphasis on use of a scoring scale. *Am J Sports Med*. 1982;10(3):150-154.
19. Malinin TI, Levitt RL, Bashore C, Temple HT, Mnaymneh W. A study of retrieved allografts used to replace anterior cruciate ligaments. *Arthroscopy*. 2002;18(2):163-170.
20. Mehta VM, Mandala C, Foster D, Petsche TS. Comparison of revision rates in bone-patella tendon-bone autograft and allograft anterior cruciate ligament reconstruction. *Orthopedics*. 2010;33(1):12.
21. Montgomery SR, Johnson JS, McAllister DR, Petrigliano FA. Surgical management of PCL injuries: indications, techniques, and outcomes. *Curr Rev Musculoskelet Med*. 2013;6(2):123-155.
22. Robbrecht C, Claes S, Cromheecke M, et al. Reliability of a semi-automated 3D-CT measuring method for tunnel diameters after anterior cruciate ligament reconstruction: a comparison between soft-tissue single-bundle allograft vs. autograft. *Knee*. 2014;21(5): 926-931.
23. Sun K, Tian S, Zhang J, Xia C, Zhang C, Yu T. Anterior cruciate ligament reconstruction with BPTB autograft, irradiated versus non-irradiated allograft: a prospective randomized clinical study. *Knee Surg Sports Traumatol Arthrosc*. 2009;17(5):464-474.
24. Sun X, Zhang J, Qu X, Zheng Y. Arthroscopic posterior cruciate ligament reconstruction with allograft versus autograft. *Arch Med Sci*. 2015;11(2):395-401.
25. Tegner Y, Lysholm J. Rating systems in the evaluation of knee ligament injuries. *Clin Orthop Relat Res*. 1985;198:43-49.
26. Wang CJ. Injuries to the posterior cruciate ligament and posterolateral instabilities of the knee. *Chang Gung Med J*. 2002;25(5):288-297.
27. Wang D, Berger N, Cohen JR, Lord EL, Wang JC, Hame SL. Surgical treatment of posterior cruciate ligament insufficiency in the United States. *Orthopedics*. 2015;38(4):e281-e286.
28. Wei J, Yang HB, Qin JB, Yang TB. A meta-analysis of anterior cruciate ligament reconstruction with autograft compared with nonirradiated allograft. *Knee*. 2015;22(5):372-379.