

Clinical Research

Comparison of Functional Outcomes With and Without Knee Bracing After Arthroscopic Anterior Cruciate Ligament Reconstruction Using a Quadriceps Tendon Autograft

Danarto Hari Adhimukti, Andri Maruli Tua Lubis, Bernadus Riyan Hartanto

Abstract

Introduction: Knee bracing after anterior cruciate ligament (ACL) reconstruction aims to maintain range of motion (ROM), provide knee stability, and protect the reconstructed ligament. However, evidence regarding the routine use of knee braces after ACL reconstruction remains limited, and no study has evaluated this practice in Indonesia. This study aimed to compare functional outcomes between patients who used a knee brace and those who did not after arthroscopic ACL reconstruction using a quadriceps tendon autograft.

Methods: This randomized controlled trial included patients undergoing arthroscopic ACL reconstruction at a tertiary hospital in Jakarta between February 2022 and February 2023. Patients were randomized to postoperative knee bracing or no bracing. Clinical outcomes were assessed preoperatively and at 1, 3, and 6 months postoperatively using the International Knee Documentation Committee (IKDC) score, Lysholm score, Knee Injury and Osteoarthritis Outcome Score (KOOS), ACL Return to Sport after Injury (ACL-RSI) score, and Rollimeter measurement.

Results: There were no significant differences between groups in sex, injured knee side, or concomitant meniscal injury. No significant between-group differences were observed in IKDC, Lysholm, or KOOS scores at any assessment point ($p > 0.05$). Rollimeter measurements showed significantly greater anterior translation in the bracing group at 1 and 3 months postoperatively ($p = 0.001$ and $p = 0.003$, respectively). A significant between-group difference in ACL-RSI scores was observed at 3 months postoperatively ($p = 0.004$).

Conclusion: Knee bracing after arthroscopic ACL reconstruction using a quadriceps tendon autograft did not improve functional outcomes compared with no bracing. Routine postoperative bracing may therefore not provide additional functional benefit.

Introduction

Anterior cruciate ligament (ACL) injuries are the most common ligament injuries in the knee region with an incidence of over 120,000 per year and resulting in 129,000 - 400,000 reconstructive surgeries in the United States and 400,000 reconstructive surgeries worldwide.¹ Anterior cruciate ligament (ACL) injuries are the most common ligament injuries in the knee region with an incidence of over 120,000 per year and resulting in 129,000 - 400,000

reconstructive surgeries in the United States and 400,000 reconstructive surgeries worldwide.²

Management of ACL injuries must be done holistically and comprehensively. Management is carried out starting from the time of ACL reconstruction surgery, graft selection during reconstruction to postoperative including brace use and rehabilitation methods used postoperatively. There are 2 types of graft that can be used Autograft and Allograft, several sources of Autograft that have been commonly

used in ACL reconstruction namely (1) Bone Patellar Tendon Bone (BPTB) which is still the gold standard of ACL reconstruction graft, (2) Hamstring, (3) Bone Quadriceps Tendon (BQT) and (4) Peroneus longus can be an alternative graft.^{3,4} Single bundle hamstring tendon (SBHT) Andri and Demy in their study stated that the use of BQT grafts had better functional outcomes when compared to Single Bundle Hamstring.³ Previous meta-analysis studies by Mouarbes et al and Zhoumao et al also stated that BQT has a lower risk of rerupture and donor-site morbidity than hamstring tendon. This could be due to the better union of the graft with the bone given its superior bone-to-bone healing properties compared to tendon-to-bone healing.^{5,6}

Postoperative management (including brace wear) to rehabilitation is as important a part of the surgery as the surgery itself. During surgery, patients should have minimal knee effusion and full extension to prevent the risk of postoperative arthrofibrosis. Patients should take the time to prepare for surgery and postoperative rehabilitation equally well. Shelbourne and Koltz explained that regaining symmetrical Range of Motion (ROM) of the knee joint is patient satisfaction.⁷

There is much debate and controversy in the use of knee brace after ACL reconstruction. In Indonesia, there is currently no research that examines the use of knee braces after ACL reconstruction. Based on this, this study examines whether there are differences in functional outcomes between patients who use a knee brace and without using a knee brace after ACL reconstruction.

Methods

The study used a randomized controlled trial design and was conducted at a tertiary hospital in Jakarta, Indonesia, from February 2022 to February 2023. The target population comprised all patients who underwent arthroscopic anterior cruciate ligament (ACL) reconstruction using a quadriceps tendon autograft during the study period. Patients who met the predefined inclusion and exclusion criteria were eligible for enrollment.

The inclusion criteria were patients aged 18–50 years with an ACL rupture without concomitant injury to other knee ligaments, including the posterior cruciate ligament (PCL), lateral collateral ligament (LCL), or medial collateral ligament (MCL), who underwent arthroscopic ACL reconstruction using a quadriceps tendon autograft. Patients with generalized joint hypermobility (Beighton score >4), a history of ACL re-rupture, or previous revision ACL reconstruction were excluded.

Participants were randomly allocated into two groups: a knee-bracing group and a non-bracing group. Randomization was performed using a computerized random-number generator (Random.org) by an independent third party, and the allocation sequence was concealed from the research-

ers.

In the bracing group, an adjustable knee brace was applied after ACL reconstruction performed by an orthopedic surgeon or orthopedic resident under specialist supervision. During the first postoperative week, the brace was locked in full extension (0°). During the third week, the target range of motion was 0°–90°, and full flexion was permitted from the fourth week onward. The brace was worn continuously during the first postoperative week, except during physical therapy sessions, according to the rehabilitation protocol.

Subjective knee function was assessed using the International Knee Documentation Committee (IKDC), Lysholm, Tegner, and Knee Injury and Osteoarthritis Outcome Score (KOOS) questionnaires. The questionnaires were administered through face-to-face interviews by an orthopedic surgeon or orthopedic resident. Clinical assessments were performed at four time points: preoperatively and at 1, 3, and 6 months postoperatively.

Knee stability was assessed using a Rolimeter. The patient was examined in the supine position, with the Rolimeter positioned over the patella and centered along the patellar level according to the manufacturer's recommended technique. Rolimeter measurements were obtained at the same four time points: preoperatively and at 1, 3, and 6 months postoperatively. Data were analyzed using the SPSS 25 program. This study was only conducted by obtaining ethical clearance from the Health Research Ethics Committee, Jakarta, before the study was carried out. This study has been registered on ClinicalTrials.gov under registration number NCT05457452.

Results

A total of 24 patients who underwent anterior cruciate ligament (ACL) reconstruction were included in the study and divided into two groups: a knee-bracing group and a non-bracing group. Most patients were male (20/24, 83.3%). The baseline characteristics of the study participants are presented in Table 1. There were no statistically significant differences in baseline characteristics between the two groups ($p > 0.05$).

The most common activity associated with ACL rupture was soccer (42%), followed by basketball (25%). The interval between injury and surgery ranged from 1 to 48 months. During the follow-up period, no cases of infection or ACL re-rupture were observed. The mean preoperative IKDC score was 46.7 ± 20.4 in the knee-bracing group and 52.8 ± 20.5 in the non-bracing group. A comparison of IKDC scores between the two groups is presented in Table 2.

KOOS scores were assessed preoperatively and at 1, 3, and 6 months after ACL reconstruction. At 1 month post-

Table 1. Research Subject Characteristics

Characteristics	Group		P-value
	Knee Brace (n=12) (%)	No Knee Brace (n=12) (%)	
Gender*			
-Male	9 (75%)	11 (91,7%)	0,590
-Female	3 (25%)	1 (8,3%)	
Age (years)**	25.5 (17-35)	23.5 (18-48)	0,191
Knee*			0,408
-Left	6 (50%)	4 (33.3%)	0,371
-Right	6 (50%)	8 (66.7%)	
Involvement meniscus injury*			
-Yes	10 (83.3%)	7 (58.3%)	0,371
-No	2 (16.7%)	5 (41.7%)	
Location of meniscus injury			
Lateral	7 (70%)	3 (42.8%)	0,371
Medial	3 (30%)	4 (57.2%)	

*Significance values were obtained with the Fisher test

**Significance values were obtained with the Mann-Whitney test

Table 2. IKDC values of patients with or without using a knee brace

IKDC Score	Brace Group N = 12	Non-Brace Group N= 12	Difference(CI 95%)	P-value
Preoperative	46.7±20.4	52.8±20.5	6.03 (-11.3 – 23.4)	0.479
Postoperative 1 month	42.8±19.1	37±18.7	-5.83 (-21.8 – 10.2)	0.459
Postoperative 3 months	59.1±13.5	60.8±12.0	1.75 (-9.1 – 12.6)	0.742
Postoperative 6 months	84.91±14.8	75.75±17.8	9.15 (-4.71 – 23.03)	0.185

*Significance value obtained by independent T-test

operatively, the median KOOS score was higher in the knee-bracing group than in the non-bracing group (56.55 [range, 13.7–82.1] vs. 42.2 [range, 15.5–84.5]); however, the difference was not statistically significant ($p=0.443$). Comparisons of KOOS scores between the two groups are presented in Table 3.

Clinical outcomes were assessed using the Lysholm score preoperatively and at 1, 3, and 6 months after ACL reconstruction. At 3 and 6 months postoperatively, there were no significant differences in Lysholm scores between the knee-bracing and non-bracing groups ($p=0.847$ and $p=0.663$, respectively). Comparisons of Lysholm scores between the knee-bracing and non-bracing groups ($p=0.847$ and $p=0.663$, respectively). Comparisons of Lysholm scores between the two groups are presented in Table 4.

Rolimeter measurements were obtained preoperatively and at 1, 3, and 6 months postoperatively. At 1 month, the mean anterior translation was greater in the knee-bracing group than in the non-bracing group (2.42 ± 0.515 mm vs. 1.50 ± 0.674 mm; $p=0.001$). At 3 months, the mean trans-

lation remained greater in the knee-bracing group (1.92 ± 0.669 mm vs. 1.17 ± 0.389 mm; $p=0.003$). A significant between-group difference was also observed at 6 months postoperatively ($p=0.024$). The results of the Rolimeter measurements are presented in Table 5.

ACL-RSI scores were assessed preoperatively and at 1, 3, and 6 months postoperatively. Preoperatively, the mean ACL-RSI score was 24.75 (18.4–30.4) in the knee-bracing group and 27.0 (24.2–45.3) in the non-bracing group, with no significant between-group difference ($p=0.143$). At 1 month, the mean scores were 51.2 (43.5–54.2) and 52.85 (43.5–55.4) in the knee-bracing and non-bracing groups, respectively, with no significant difference ($p=0.311$). At 3 months, a significant between-group difference was observed ($p=0.004$). At 6 months, the difference was no longer statistically significant ($p=0.355$). The ACL-RSI results are presented in Table 6.

Discussion

This study involved 24 subjects divided into two groups: those using post-operative braces (12 subjects) and those

Table 3. KOOS value of patients with or without using a knee brace

KOOS	Brace Group N = 12	Non-Brace Group N= 12	Differences	P-value
Preoperative				
Symptoms	66.3 (22.7)	57.7 (21.5)	8.62 (-10.1 - 27.3)	0.350
Pain	68.5 (21.4)	62.2 (22.5)	6.24 (-12.4 - 24.8)	0.494
ADL	66.2 (22.5)	62.0 (22.0)	4.28 (-14.6 - 23.1)	0.642
Exercise	60.8 (29.8)	50.4 (32.1)	10.4 (-15.8 - 36.6)	0.419
Quality of life	63.0 (27.3)	51.5 (21.1)	11.4 (-9.25 - 32.1)	0.264
Total	65.2 (20.3)	59.2 (21.4)	5.99 (-11.7 - 23.7)	0.489
Postoperative 1 month				
Symptoms	53.8 (20.3)	53.5 (18.5)	0.29 (-16.2 - 16.7)	0.970
Pain	52.4 (27.3)	45.6 (20.2)	6.80 (-13.6 - 27.2)	0.496
ADL	50.7 (19.8)	44.3 (16.0)	6.37 (-8.90 - 21.6)	0.396
Exercise	37.5 (26.4)	22.5 (28.5)	15 (-8.29 - 38.2)	0.195
Quality of life	48.9 (23.6)	41.1 (23.9)	7.81 (-12.3 - 27.9)	0.429
Total	52.4 (22.2)	44.7 (17.8)	7.73 (-9.36 - 24.8)	0.358
Postoperative 3 months				
Symptoms	81.5 (11.8)	78.5 (14.4)	2.97 (-8.22 - 14.1)	0.587
Pain	73.3 (16.3)	72.7 (12.1)	0.65 (-11.5 - 12.8)	0.911
ADL	75.8 (8.08)	74.1 (7.86)	1.71 (-5.04 - 8.46)	0.604
Exercise	60 (28.6)	48.3 (22.7)	11.6 (-10.2 - 33.6)	0.282
Quality of life	65.6 (11.1)	66.1 (13.1)	-0.5 (-10.8 - 9.81)	0.917
Total	73.7 (10.2)	70.9 (9.64)	2.78 (-5.65 - 11.2)	0.501
Postoperative 6 months				
Symptoms	94.04 (4.3)	91.96 (8.4)	2.08 (-3.64 - 7.81)	0.458
Pain	91.66 (11.8)	91.20 (6.3)	3.88 (-7.58 - 8.50)	0.907
ADL	92.89 (11.4)	92.64 (6.2)	3.75 (-7.53 - 8.02)	0.948
Exercise	81.66 (20.0)	68.33 (29.1)	10.2 (-7.82 - 34.4)	0.205
Quality of life	87.14 (12.2)	76.56 (26.3)	8.39 (-6.83 - 27.9)	0.221
Total	89.48 (11.4)	84.14 (13.8)	5.19 (-5.45 - 16.1)	0.351

*Significance values were obtained with the Mann Whitney test

not using braces (12 subjects). The majority of participants were male, with an average age of 23-25 years, reflecting the population of previous ACL injury patients, typically adolescents or young adults engaged in competitive sports. The research highlighted that knee injuries, particularly ACL injuries, play a significant role in sports-related injuries. While previous studies suggested a higher incidence of ACL injuries in females, more males undergo ACL surgery possibly due to the lower participation rate of females, especially in competitive sports, compared to males. The study also emphasized that there was no significant difference in the location of ACL injuries between the left and right sides, with meniscus injuries often accompanying ACL injuries, predominantly affecting the lateral meniscus. Meniscus injuries were more common in ACL injuries lasting over 8 weeks, signifying an increased risk associated with ACL rupture.⁸⁻¹⁰

Clinical outcome assessment in this study was conducted through rolimeter testing, indicating anterior translation of the knee joint, signaling joint laxity due to ACL damage.

The research revealed significant differences in rolimeter measurements between the brace and non-brace groups at the 1-month and 3-month evaluations following the ACL injury. Initially, both groups showed considerable anterior translation of around 8.92 mm in the brace group and 8.58 mm in the non-brace group. However, statistically, no significant differences in anterior translation were observed preoperatively, indicating a comparable baseline between the two groups. At the 1-month evaluation, a significant difference in translation was noted with a mean difference of 0.9 mm between the brace and non-brace groups. Interestingly, the brace group exhibited significantly higher translations than the non-brace group. Despite the significant differences, postoperative rolimeter measurements in this study showed average anterior translations of 2.42 mm and 1.50 mm in both groups, within normal limits compared to prior research. A study by Lubis et al. in Indonesia displayed a larger postoperative anterior translation of 3.12 mm following cruciate ligament reconstruction with bone quadriceps tendon, further emphasizing the satisfactory outcomes of this study within a normal range.^{3,11}

Table 4. Tegner Lysholm score value of the patient with or without using a knee brace

Tegner Scale	Brace Group N = 12	Non-Brace Group N= 12	P-value
Preoperative			
Bad	3 (25)	7 (58)	0.518
Average	8 (66)	2 (16)	
Good	1 (8)	3 (25)	
Very good	0 (0)	0 (0)	
Postoperative 1 month			
Bad	6 (50)	8 (66)	0.996
Average	5 (41)	4 (33)	
Good	1 (8)	0 (0)	
Very good	0 (0)	0 (0)	
Postoperative 3 month			
Bad	3 (25)	0 (0)	0.847
Average	4 (33)	9 (75)	
Good	4 (33)	3 (25)	
Very good	0 (0)	0 (0)	
Postoperative 6 month			
Bad	0 (0)	0 (0)	0,663
Average	1 (8.3)	3 (25)	
Good	6 (50)	4 (33.3)	
Very good	5 (41.7)	5 (41.7)	

*Significance values were obtained with the Mann Whitney test

Table 5. Rollimeter examination in patients with or without using a knee brace

Rollimeter (mm)	Brace Group N = 12	Non-Brace Group N= 12	Mean difference (95% IK)	P-value
Preoperative	8.92 (1.929)	8.58 (1.505)	0.33 (-1.1 - 1.79)	0.642
Postoperative 1 month	2.42 (0.515)	1.50 (0.674)	0.91 (0.40 - 1.42)	0.001
Postoperative 3 month	1.92 (0.669)	1.17 (0.389)	0.75 (0.28 - 1.21)	0.003
Postoperative 6 month	1.66 (0.77)	1.08 (0.28)	0.23 (0.08 – 1.08)	0.024

*Significance values were obtained with the Independent T-test

Table 6. ACL-RSI Score value of patients with or without using a knee brace

ACL-RSI Score	Brace Group N = 12	Non-Brace Group N= 12	Mean Difference	P Value
Preoperative	24.75 (18.4-30.4)	27 (24.2-45.3)	-3.08 (-7.1 - 0.9)	0.141
Postoperative 1 month	51.2 (43.5-54.2)	52.85 (43.5-55.4)	-0.94 (-4.1 - 2.2)	0.311
Postoperative 3 month	73.1 (64.9-77.3)	65.9 (63.2-74.2)	5.42 (2.3 – 8.5)	0.004
Postoperative 6 month	67.3 (38.3-82.5)	63.2 (50.8-88.3)	2.39 (-7.0 – 11.8)	0.355

*Significance values obtained with the Mann Whitney test

Similar findings were also found in the 3-month postoperative rollimeter assessment with significant differences. Previous research has described anterior translation exceeding 3 mm in subjects undergoing ACL reconstruction. The results here indicate that the residual translation observed may not be clinically significant, especially when the mean translation remains within normal limits. In contrast, a study by Jacobi et al. in 2016 reported significant-

ly better rollimeter results in patients receiving post-ACL reconstruction bracing. This difference may be attributed to the varying durations of follow-up, as their study had a 2-year follow-up period.^{12,13}

While significant differences were noted between the brace and non-brace groups, there were no observable variations in functional outcomes. This implies that

despite differing knee stability as measured by anterior translation, functional outcomes were not impacted. Interestingly, functional outcomes were superior in the brace group, despite poorer clinical outcomes, highlighting the beneficial effect of brace use in providing ACL support and improving knee stability. Assessment via various scores like IKDC, KOOS, Tegner Lysholm, and ACL-RSI showed differing outcomes. The IKDC score, evaluating subjective and objective aspects of the knee, displayed comparable baseline function preoperatively. Post-ACL reconstruction, a decrease in IKDC scores was noted, consistent with previous findings of improving postoperative IKDC scores reported in the literature. This study corroborates a similar trend with decreased IKDC scores at the 1-month evaluation post-surgery, potentially related to common post-ACL reconstruction knee pain.¹⁴⁻¹⁷

Observations in this study show that, at the 1-month postoperative evaluation, the non-brace group had lower IKDC scores compared to the brace group, although this difference was not statistically significant. This suggests that brace use may still offer clinical benefits in terms of functional outcomes one month after surgery. However, previous research supports the statistical outcomes indicating no significant correlation between post-ACL operation brace use and IKDC scores. This study aligns with a meta-analysis of randomized controlled trials by Yang et al. in 2019, asserting that brace utilization does not enhance IKDC functional outcomes in patients following ACL arthroscopic reconstruction. The study emphasized that bracing's effects were only relative during wear, lacking significant long-term benefits. Earlier research by Moller et al. also highlighted that patients using braces face higher risks of tissue swelling due to soft tissue compression, associated with lower limb muscle atrophy and reduced knee joint flexion range of motion.¹⁸⁻²⁰

This study compared the functional outcomes between brace and non-brace groups following ACL reconstruction, utilizing the KOOS scoring system to assess differences at preoperative, 1-month, and 3-month postoperative stages. The KOOS system, which evaluates symptoms, pain, daily activities, sports, and knee-related quality of life, showed no significant differences between the groups. Although prior research suggested that brace use post-reconstruction could lead to functional improvement, this study did not find a significant correlation between brace usage and KOOS scores, including in areas such as pain and sports activities, where the non-brace group showed better recovery at 1-month post-operation. This aligns with previous findings emphasizing the benefits of brace use in enhancing functional outcomes, particularly in the sports domain, at longer follow-up periods.²¹⁻²³

This study evaluated post-operative outcomes using the Tegner Lysholm Knee Scoring and ALC-RSI scores, finding that the use of bracing did not significantly impact outcomes except for psychological factors measured by

the ALC-RSI three months post-ACL reconstruction. The ALC-RSI assesses the psychological readiness of patients with ACL injuries to return to sports, including emotions, confidence levels, and risk assessment, where brace users showed significantly better psychological readiness at three months. This indicates a potential positive psychological impact of bracing on returning to sports activities. Despite this, previous research has shown no long-term functional difference in patients post-ACL reconstruction with or without brace use, suggesting that while bracing might improve psychological confidence in the short-term, it doesn't necessarily translate into long-term functional improvements.²⁴⁻²⁸

Research suggests that the utility of knee braces following ACL reconstruction surgery is dependent on the duration and manner of use to achieve optimal outcomes. According to a study by Masini et al., braces should be worn constantly for 4-8 weeks post-surgery, except during bathing or physical therapy sessions, with the knee held in maximum extension for better functional outcomes compared to a 0-90 degree flexion position. This study found no incidents of re-rupture post-ACL reconstruction, contrasting with previous studies like Balendra et al., which reported a 5.2% graft rupture rate within the first year, often before returning to competitive sports, highlighting the highest risk of graft failure within the first 12 months post-reconstruction. The causes of graft failure are multifactorial, with factors including the injury's initial contact mechanism and the return to sports impacting the risk of recurrent ACL rupture. Patients with initial contact mechanism injuries face a threefold risk of graft re-rupture, potentially due to differences in tendon properties, such as the quadriceps tendon's higher elasticity and thickness compared to other tendons and the normal ACL.²⁹⁻³²

This research is a randomized controlled trial that specifically investigates the subjective and objective functional outcomes of patients using a brace versus those not using a brace after undergoing arthroscopic ACL reconstruction with an autograft from the quadriceps tendon. It's noteworthy that clinical studies detailing the specific impact of brace use on patients following arthroscopic ACL reconstruction with quadriceps tendon autografts have not been previously reported, making this study a primary data source for future research. However, the study faces limitations, including a short follow-up duration of three months and inconsistent post-operative rehabilitation protocols across patients. For more conclusive findings, further research is recommended with a longer follow-up period and more homogenous subject groups, such as athletes or younger individuals.

Conclusion

There were no significant differences in functional outcomes, as assessed by the IKDC, Lysholm, and KOOS scores, between patients who used a knee brace and those

who did not after arthroscopic ACL reconstruction using a quadriceps tendon autograft. Significant between-group differences were observed in ACL-RSI scores at 3 months and in Rolimeter measurements at 1, 3, and 6 months post-operatively. Overall, routine knee bracing did not provide a significant functional benefit following ACL reconstruction with a quadriceps tendon autograft.

References

1. Lowe WR, Warth RJ, Davis EP, Bailey L. Functional bracing after anterior cruciate ligament reconstruction: a systematic review. *J Am Acad Orthop Surg.* 2017;25(3):239-249.
2. Kaeding CC, Léger-St-Jean B, Magnussen RA. Epidemiology and diagnosis of anterior cruciate ligament injuries. *Clin Sports Med.* 2017;36(1):1-8.
3. Lubis AM, Dasril DF. Comparison of functional outcome between bone quadriceps tendon (BQT) and single-bundle hamstring tendon (SBHT) autograft in arthroscopic-assisted anterior cruciate ligament reconstruction cases: a prospective cohort study. *Ann Med Surg (Lond).* 2020;60:509-514.
4. Rudy, Mustamsir E, Phatama KY. Tensile strength comparison between peroneus longus and hamstring tendons: a biomechanical study. *Int J Surg Open.* 2017;9:41-44.
5. Mouarbes D, Menetrey J, Marot V, Courtot L, Berard E, Cavaignac E. Anterior cruciate ligament reconstruction: a systematic review and meta-analysis of outcomes for quadriceps tendon autograft versus bone-patellar tendon-bone and hamstring-tendon autografts. *Am J Sports Med.* 2019;47(14):3531-3540.
6. Hurley ET, Mojica ES, Kanakamedala AC, Meislin RJ, Strauss EJ, Campbell KA, et al. Quadriceps tendon has a lower re-rupture rate than hamstring tendon autograft for anterior cruciate ligament reconstruction: a meta-analysis. *J ISAKOS.* 2022;7(2):87-93.
7. Scott WN, editor. *Insall & Scott surgery of the knee.* 6th ed. Philadelphia: Elsevier; 2018.
8. Sayampanathan AA, Howe BKT, Bin Abd Razak HR, Chi CH, Tan AHC. Epidemiology of surgically managed anterior cruciate ligament ruptures in a sports surgery practice. *J Orthop Surg (Hong Kong).* 2017;25(1):230949901668428.
9. Hagino T, Ochiai S, Senga S, Yamashita T, Wako M, Ando T, et al. Meniscal tears associated with anterior cruciate ligament injury. *Arch Orthop Trauma Surg.* 2015;135(12):1701-1706.
10. Dumont GD, Hogue GD, Padalecki JR, Okoro N, Wilson PL. Meniscal and chondral injuries associated with pediatric anterior cruciate ligament tears. *Am J Sports Med.* 2012;40(9):2128-2133.
11. Pollet V, Barrat D, Meirhaeghe E, Vaes P, Handelberg F. The role of the Rolimeter in quantifying knee instability compared to the functional outcome of ACL-reconstructed versus conservatively-treated knees. *Knee Surg Sports Traumatol Arthrosc.* 2005;13(1):12-18.
12. Cummings JF, Grood ES. The progression of anterior translation after anterior cruciate ligament reconstruction in a caprine model. *J Orthop Res.* 2002;20(5):1003-1008.
13. Jacobi M, Reischl N, Rönn K, Magnusson RA, Gautier E, Jakob RP. Healing of the acutely injured anterior cruciate ligament: functional treatment with the ACL-Jack, a dynamic posterior drawer brace. *Adv Orthop.* 2016;2016:9076525.
14. Strutzenberger G, Braig M, Sell S, Boes K, Schwameder H. Effect of brace design on patients with ACL ruptures. *Int J Sports Med.* 2012;33(11):934-939.
15. Hefti E, Müller W, Jakob RP, Stäubli HU. Evaluation of knee ligament injuries with the IKDC form. *Knee Surg Sports Traumatol Arthrosc.* 1993;1(3-4):226-234.
16. Singh K, Singh V. Outcome assessment after anterior cruciate ligament reconstruction among non-athletes. *Int J Contemp Med Res.* 2020;7(10).
17. Gadea F, Monnot D, Quélard B, Mortati R, Thaumat M, Fayard JM, et al. Knee pain after anterior cruciate ligament reconstruction: evaluation of a rehabilitation protocol. *Eur J Orthop Surg Traumatol.* 2014;24(5):789-795.
18. Di Miceli R, Marambio C, Zati A, Monesi R, Benedetti M. Do knee bracing and delayed weight bearing affect mid-term functional outcome after anterior cruciate ligament reconstruction? *Joints.* 2017;5(4):202-206.
19. Lun DX, Hu YC, Yang XG, Wang Z, Yu XC, Wu SJ, et al. Development and proposal of a scoring system for giant cell tumour of the bone around the knee. *Int Orthop.* 2018;42(1):203-213.
20. Yang XG, Feng JT, He X, Wang F, Hu YC. The effect of knee bracing on the knee function and stability following anterior cruciate ligament reconstruction: a systematic review and meta-analysis of randomized controlled trials. *Orthop Traumatol Surg Res.* 2019;105(6):1107-1114.
21. Roos EM, Lohmander LS. The Knee injury and Osteoarthritis Outcome Score (KOOS): from joint injury to osteoarthritis. *Health Qual Life Outcomes.* 2003;1:64.
22. Desai N, Björnsson H, Samuelsson K, Karlsson J, Forssblad M. Outcomes after ACL reconstruction with focus on older patients: results from the Swedish National Anterior Cruciate Ligament Register. *Knee Surg Sports Traumatol Arthrosc.* 2014;22(2):379-386.
23. Wright RW, Huston LJ, Nwosu SK, Allen CR, Anderson AF, Cooper DE, et al. Rehabilitation predictors of clinical outcome following revision ACL reconstruction in the MARS cohort. *J Bone Joint Surg Am.* 2019;101(9):779-786.
24. Hopper GP, Aithie JMS, Jenkins JM, Wilson WT, Mackay GM. Combined anterior cruciate ligament repair and anterolateral ligament internal brace augmentation: minimum 2-year patient-reported outcome measures. *Orthop J Sports Med.*

- 2020;8(12):2325967120968913.
25. Sadeqi M, Klouche S, Bohu Y, Herman S, Lefevre N, Gerometta A. Progression of the psychological ACL-RSI score and return to sport after anterior cruciate ligament reconstruction: a prospective 2-year follow-up study from the French prospective anterior cruciate ligament reconstruction cohort study (FAST). *Orthop J Sports Med.* 2018;6(12):232596711881281.
26. McDevitt ER, Taylor DC, Miller MD, Gerber JP, Ziemke G, Hinkin D, et al. Functional bracing after anterior cruciate ligament reconstruction. *Am J Sports Med.* 2004;32(8):1887-1892.
27. Yapıcı F, Gür V, Sarı İF, Köksal A, Yurten H, Üçpunar H, et al. Prescription of knee braces after anterior cruciate ligament reconstruction: fact or fiction? *Turk J Phys Med Rehabil.* 2022;68(3):355-363.
28. Kinikli G, Callaghan M, Parkes M, Yuksel I. Bracing after anterior cruciate ligament reconstruction: systematic review and meta-analysis. *Turkiye Klin J Sports Sci.* 2014;6:28-38.
29. Masini BD, Owens BD. Current recommendations for anterior cruciate ligament bracing: when to use. *Phys Sportsmed.* 2013;41(1):35-39.
30. Balendra G, Jones M, Borque KA, Willinger L, Pinheiro VH, Williams A. Factors affecting return to play and graft re-rupture after primary ACL reconstruction in professional footballers. *Knee Surg Sports Traumatol Arthrosc.* 2022;30(7):2200-2208.
31. Salmon L, Russell V, Musgrove T, Pinczewski L, Refshauge K. Incidence and risk factors for graft rupture and contralateral rupture after anterior cruciate ligament reconstruction. *Arthroscopy.* 2005;21(8):948-957.
32. Cohen D, Slawaska-Eng D, Almasri M, Sheean A, de Sa D. Quadriceps ACL reconstruction techniques and outcomes: an updated scoping review of the quadriceps tendon. *Curr Rev Musculoskelet Med.* 2021;14(6):462-474.