Reconstruction of partial anterior cruciate ligament tears: systematic review

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Abstract

Background: Partial anterior cruciate ligament (ACL) tears represent a unique subset of ACL injuries, with increasing attention toward tissue-preserving surgical techniques. Traditional management through complete ACL reconstruction may overlook the potential benefits of maintaining native fiber integrity.

Aim: This study aimed to systematically review the literature on clinical outcomes of partial ACL reconstruction and compare them with outcomes of complete reconstruction and other surgical alternatives.

Methods: A systematic review was conducted following PRISMA guidelines. Multiple databases were searched for studies involving surgical treatment of arthroscopically confirmed partial ACL tears. Inclusion criteria were clinical studies reporting surgical interventions (e.g., selective bundle reconstruction, augmentation, or primary repair), with a minimum follow-up of 12 months. Data on study characteristics, diagnostic methods, interventions, outcome measures, and results were extracted and synthesized descriptively.

Results: Five studies (n = 240 patients) were included, with follow-up durations ranging from 12 months to over 10 years. Subjective and objective outcomes of partial ACL reconstruction were generally comparable to those of complete reconstruction. Tools such as IKDC, Lysholm, KOOS, KT-1000 arthrometer, and KiRA accelerometer were commonly used. Some studies reported reduced tunnel widening and better anterior laxity control with augmentation techniques. Primary repair showed promising results but had a relatively higher rate of secondary ACL insufficiency.

Conclusion: Partial ACL reconstruction offers similar functional outcomes to complete reconstruction, with potential advantages in preserving native anatomy and knee stability. Further multicenter randomized studies are needed to confirm long-term efficacy and define optimal surgical indications.

Keywords: Partial ACL tear, selective bundle reconstruction, augmentation, ACL repair, anterior cruciate ligament, clinical outcomes, systematic review

Introduction:

Anterior cruciate ligament (ACL) injury is one of the most prevalent knee injuries among young athletes. Most patients with acute ACL injuries are younger than 30, and such injuries therefore result in early onset osteoarthritis **(1,2)**. This posttraumatic osteoarthritis has a significant associated morbidity and healthcare cost **(3)**. In the United States alone, there are estimated to be between 120,000 and 400,000 ACL reconstructions per year **(4)**. Fixed object

high-impact rotational landing sports such as gymnastics and obstacle course racing as well as athlete-to-athlete contact sports are thought to result in the highest rates of ACL injury **(5)**. The current gold standard of treatment for ACL rupture is reconstruction performed soon after injury to limit further meniscal or cartilage damage **(6)**.

The extent of ACL injuries varies widely, from complete to partial tears. While the definition of partial tear remains controversial, certain literature has described partial tear as the rupture of either the anteromedial (AM) or posterolateral (PL) bundle while the other bundle remains intact **(7)**. The anteromedial (AM) and posterolateral (PL) bundles of an Anterior cruciate ligament (ACL) are characterized by different injury mechanisms due to their different course and biomechanical functions **(8)**.

Historically, reconstruction of partial ACL injuries was characterized by remnant bundle sacrificing and new graft implantation to replace the entire ACL. Importantly, several factors relating to the reconstructed bundle such as graft configuration and single bundle (SB) versus double bundle (DB) reconstruction have been studied in partial tears **(8,9)**.

More recently, in partial ACL injuries, many surgeons perform ACL augmentation (AUG), which consists of an isolated AM or PL reconstruction suturing the graft remnants. This procedure involves increased difficulty and precision in orienting the bone tunnels to avoid damaging the native bundle insertion site. However, in experienced hands, it results in only a modest lengthening of surgical time **(10,11)**.The basic principle is that preserving native ACL fibers may contribute to healing and graft integration by creating an ideal environment for cell growth at the ligament insertion site and may improve proprioception **(12)**.

In recent decades, the issue of remnant preservation has been raised, and several papers have focused on treating partial ACL tears **(13–15)**.

Given the increasing interest in tissue-preserving approaches, several studies have investigated the outcomes of partial ACL reconstruction. However, evidence remains varied in terms of techniques, outcomes, and indications. This review aims to evaluate the clinical outcomes of partial anterior cruciate ligament (ACL) reconstruction in patients with arthroscopically confirmed partial tears. It further compares these outcomes with those of complete ACL reconstruction and alternative surgical techniques, including augmentation and primary repair. The review also explores whether partial reconstruction confers advantages in preserving native ligament anatomy, minimizing surgical morbidity, improving knee stability, and facilitating faster functional recovery.

Methods:

This study was conducted following the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines **(Figure 1)**.

Search strategy: A comprehensive literature search was conducted across multiple databases to identify relevant studies. The search strategy included combinations of the following keywords and Boolean operators were used, such as: ("partial ACL tear" OR "partial anterior cruciate ligament tear") AND ("reconstruction" OR "selective bundle reconstruction" OR "augmentation" OR "remnant-preserving") AND ("clinical outcomes" OR "functional outcomes" OR "knee stability" OR "return to sport"). The search was limited to English-language articles published in peer-reviewed journals with no restriction on publication year. Additionally, manual searches of reference lists from relevant articles also were performed to identify additional studies.

Inclusion Criteria: Studies were included if they met the following criteria: (1): Clinical studies involving human subjects diagnosed with partial ACL tears (confirmed arthroscopically). (2): Studies reporting on surgical interventions (e.g., selective bundle reconstruction, augmentation, or primary repair). (3): Studies that provided clinical outcomes, whether subjective or objective. (4): Minimum follow-up duration of 12 months. (5): Original articles (prospective, retrospective, or case series) published in peer-reviewed journals.

Exclusion Criteria: Studies were excluded if they: Studies were excluded if they met any of the following: (1): Studies focusing solely on complete ACL tears without a separate analysis of partial injuries. (2): Non-clinical or animal studies, biomechanical studies, or cadaveric models. (3): Reviews, editorials, letters to the editor, case reports with fewer than 5 patients. (4): Studies lacking clear intervention description or outcome reporting. (5): Articles not available in English or with inaccessible full text.

Data extraction: Two researchers conducted separate assessments of the titles and abstracts of all the papers generated to determine their relevance. We thoroughly examined each trial that was discovered and decided about whether to include it or not. Researchers also independently extracted the data into a standardized data extraction form. The two reviewers established a consensus on decisions about the inclusion of research and data extraction. The 3rd researcher would have the final authority to determine trial eligibility and extract data where discrepancies have been discovered.

Results

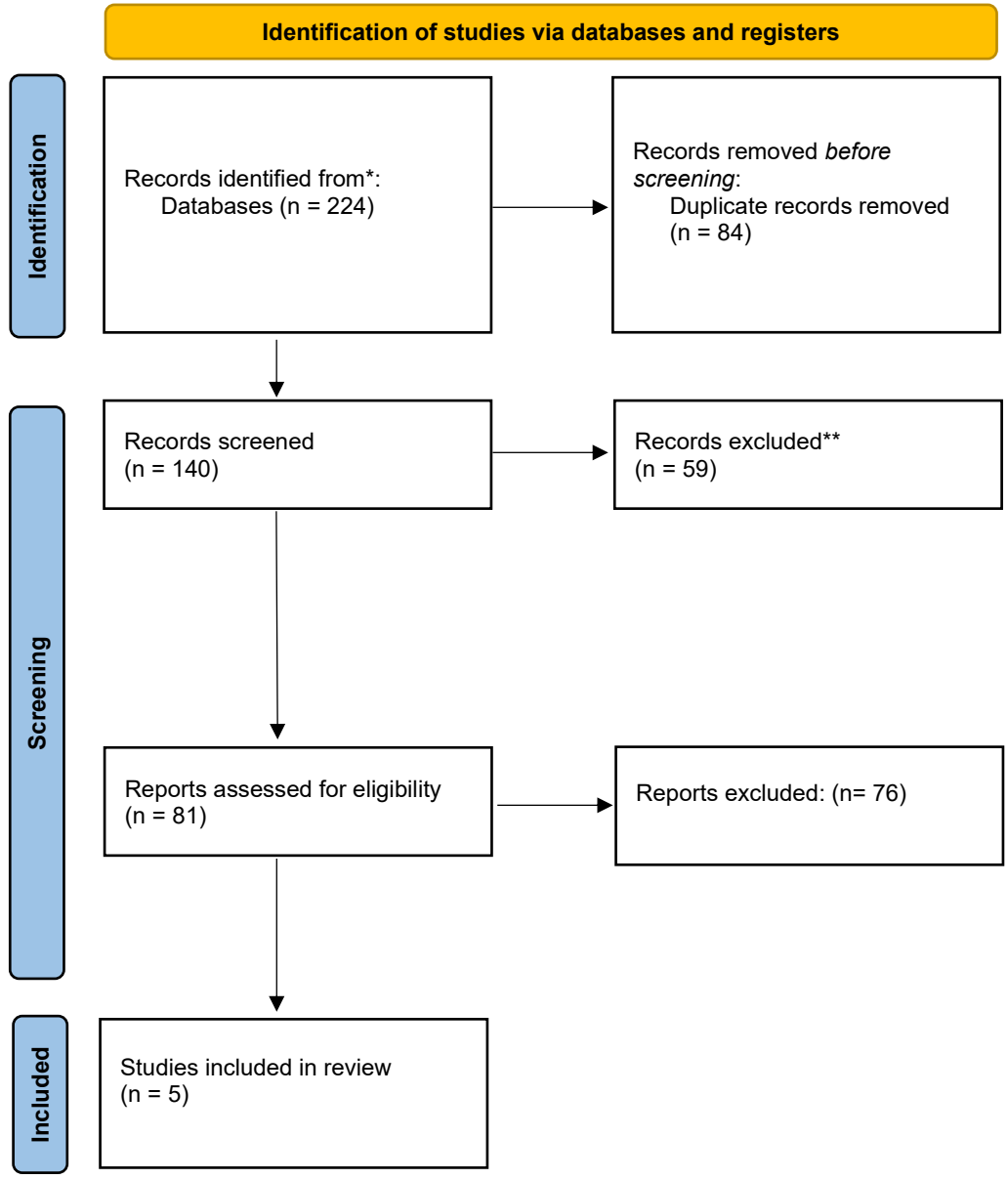

Figure 1: Represents PRISMA flow chart for study selection process.

Table 1: Characteristics of included studies

Study ID	Year	Country	Study design	Sample size	Age	Gender
Pujol et al., (16)	2012	France	Multicenter prospective randomized	54	30 years (range, 18—46 yrs)	33 male patients and 21 female
Carulli et al., (17)	2020	Italy	Retrospective	36	26.4 years (15–37 years)	30 males, 6 females
Demirağ et al., (18)	2012	Turkey	Prospective randomized	40	30 years; range 19 to 40 years)	(36 males, 4 females)
Gobbi et al., (19)	2018	Italy	Case series	50	mean age, 29.5 years	36 male and 14 female
Berruto et al., (20)	2015	Italy	retrospective, comparative cohort study	60	Range, (17–55 years).	47 male and 13 female

Table 2: Surgical intervention types, diagnostic methods, and follow-up duration

Study ID	Intervention type	Diagnostic method	Follow-up duration
Pujol et al., (16)	Selective AM bundle reconstruction (group 1)vs. standard anatomic single-bundle reconstruction (group 2)	Clinical exam (Lachman + negative pivot shift) + MRI + confirmation by arthroscopy	6 months and 1 year
Carulli et al., (17)	Selective reconstruction of a single ACL bundle	Clinical + MRI evaluation, confirmed by arthroscopy	64 months (48–84 months)
Demirağ et al., (18)	Standard SB reconstruction (G1) vs. remnant-preserving augmentation (G2), both using hamstring autografts	Clinical (physical) examination + MRI + confirmation via arthroscopy (≥1/2 ACL integrity preserved)	24.3 months (range; 21-28 months)
Gobbi et al., (19)	Primary ligament repair in conjunction with marrow stimulation	Clinical examination (Lachman, glide jerk test, anterior laxity) + MRI + confirmation via arthroscopy (bundle probing and visualization)	10.2 years (range, 5.3-14.3 years)
Berruto et al., (20)	ACL partial reconstruction surgery (group 1) vs. a complete	Arthroscopic confirmation of partial ACL tear (AM	Minimum follow-up of 12 months

	reconstruction with a BPTB (group 2) vs. autologous HT (group 3) graft	or PL bundle involvement)	

Table 3: Outcome measures used, reported results, and authors' conclusions

Study ID	Outcome measures used	Main findings	Authors conclusion
Pujol et al., (16)	IKDC (subjective/objective), Lysholm, KOOS and Rolimeter	In the two intervention type groups respectively; IKDC ↑ from 55.8/56.8 to 86.2/85.7; Lysholm ↑ from 69.9/71.1 to 90.9/91.8. Laxity ↓ from 5.0/5.1 mm to 1.2/1.9 mm. Differences in subjective scores were not significant; laxity difference was statistically significant (P=0.03)	Selective AM bundle reconstruction conserving the posterolateral bundle remnant provides clinical results comparable to the standard single-bundle technique, with better control of anterior laxity. Longer follow-up needed
Carulli et al., (17)	IKDC, KOOS, KT2000® arthrometer and SF-12, return to sport (yes/no questionnaire)	All patients but one achieved good functional recovery and returned to their sports within a mean period of 6.1 months. A single patient complained of postoperative instability 1 year after the index operation and needed further surgery. No complications were recorded.	Selective reconstruction of partial ACL injury is a method to bear in mind because it offers quick functional recovery.
Demirağ et al., (18)	IKDC, Lysholm score, ROM, Lachman test, pivot-shift test, patient satisfaction, Shelbourne classification (arthrofibrosis), radiographic tunnel widening	No significant differences were found between groups regarding IKDC, Lysholm, physical instability tests, patient satisfaction, and incidences of Cyclops lesions or arthrofibrosis. Tibial and femoral tunnel widening was less in the augmentation	In the repair of partial ACL tears, augmentation technique is as effective as the standard technique, leading to, less tunnel widening evidently in the tibial tunnel, particularly.

		group, with a more significant difference on the tibial side.	
Gobbi et al., (19)	Tegner Activity Scale, Marx Activity Rating Scale, Lysholm Knee Questionnaire, IKDC Subjective score, KOOS(subsets of Pain, Symptoms, ADL, QOL), Rolimeter (anterior laxity measurement.	The median Tegner score remained unchanged from preinjury (7; P = .128). Mean scores were: Marx = 10.8, IKDC Subjective = 90.4, Lysholm = 96.2. KOOS subset scores were: Pain = 98.6, Symptoms = 97.5, ADL = 99.7, Sports = 94.3, QoL = 95.6. Secondary ACL insufficiency occurred in 27%. No significant correlations were found between outcome scores and age, BMI, tear type, or laxity. Higher laxity at short-term follow-up (mean 3.4 mm) was associated with later failure versus 0.9 mm in others (P = .010).	Primary ACL repair with biologic healing augmentation yielded good to excellent long-term outcomes in patients without secondary ACL insufficiency, with high rates of restored knee stability and return to preinjury athletic levels. However, the rate of secondary ACL insufficiency requiring further treatment was higher than typically expected with primary ACL reconstruction. Greater side-to-side differences laxity were identified at shorter term follow-up in the patients who later went on to experience symptomatic secondary ACL insufficiency, compared with those who maintained stability long term
Berruto et al., (20)	Lysholm, IKDC, VAS, Tegner, KT-1000, KiRA	The mean subjective IKDC score was 86.1±10.3 in group 1, 85.2±11.1 in group 2, and 82.7±7.8 in group 3. The Lysholm score was 91.3±7.3 in group	Both subjective and objective outcomes of partial ACL reconstruction were comparable to those of complete reconstruction.

		1, 91.7±9.6 in group 2, and 89.4±6.1 in group 3. KT-1000 tests showed a mean side-to-side difference of 1.1 mm ± 1.5 mm (range, 0–5 mm) in group 1; 0.79 mm ± 0.8 mm (range, 0–2mm) in group 2; and 1.45 mm ± 1 mm (range, 0–3 mm) in group 3. The differences between groups were not statistically significant.	However, partial reconstruction was considered more respectful of native ACL vascularization, innervation, and anatomy, conferring an advantage in terms of recovery of the complete function of the knee.

Discussion

The anterior cruciate ligament (ACL) plays a critical role as a stabilizer in the knee, preventing anterior tibial translation and maintaining rotational stability **(21)**. This systematic review evaluated surgical outcomes in patients with arthroscopically confirmed partial anterior cruciate ligament (ACL) tears. The surgical interventions assessed included selective bundle reconstruction, augmentation techniques, and primary ACL repair, compared to standard complete ACL reconstruction.

Across the included studies, partial ACL reconstruction demonstrated clinical outcomes that were comparable to complete reconstruction in terms of subjective and objective measures, including IKDC, Lysholm, and KT-1000 or KiRA assessments **(20)**. several studies reported that partial ACL reconstruction, particularly with remnant-preserving techniques, provided similar or even superior clinical results compared to standard complete reconstruction, often allowing for quick functional recovery **(16,17)**. **Demirağ et al., (18)** similarly found that augmentation techniques were as effective as the standard approach, with added advantages. Specific benefits were noted in some cases, such as reduced tunnel widening **(18)**, better anterior laxity control **(16)**, and rapid return to sport **(17)**.

In contrast, **Gobbi et al., (19)** reported a 27% rate of secondary ACL insufficiency following biologic healing augmentation, suggesting that outcomes may vary with technique and patient selection.

When compared with previous systematic reviews and meta-analysis, **Bosco et al., (22)** who evaluated the current evidence on the effectiveness of ACL augmentation compared with standard ACL reconstruction to assess whether ACL augmentation may be the treatment of choice in partial ACL injury. They found that ACL augmentation has proved to be an effective and safe procedure and should be preferred to ACL reconstruction in partial ACL tears for the tendency to achieve better functional outcomes. Similarly, **Yeo et al., (7)** provided valuable insight to the management of partial tears. Their findings demonstrated that the preservation of the intact bundle offers stability and function that is as good as complete reconstruction and that SLB is a potentially viable option in the management of partial tears.

Clinical Implications: Based on the findings of this review, partial ACL reconstruction, particularly remnant-preserving techniques, can be considered a viable surgical option in patients with arthroscopically confirmed partial ACL tears. When the remaining bundle appears structurally competent and well-vascularized, selective reconstruction may provide equivalent or even superior functional outcomes compared to complete reconstruction.

Therefore, surgeons may consider partial reconstruction in carefully selected cases to preserve native tissue, enhance proprioception, and potentially support faster recovery.

Conclusion:

Partial ACL reconstruction demonstrates clinical outcomes comparable to complete reconstruction in terms of subjective and objective measures. Several studies suggest potential advantages of partial reconstruction in preserving native ligament anatomy, vascularization, and proprioception. These findings suggest that partial reconstruction is a valid and effective surgical option in patients with arthroscopically confirmed partial ACL tears.

Points of Strength:

1. Inclusion of studies with various surgical techniques (augmentation, selective bundle reconstruction, primary repair).
2. Use of both subjective and objective outcome measures across studies (e.g., IKDC, Lysholm, KT-1000, KiRA).
3. Long follow-up duration in multiple studies, up to over 10 years.
4. Consistent use of arthroscopic confirmation for diagnosis in all included studies.

Limitations:

1. Heterogeneity in surgical techniques and graft types across studies.
2. Variability in outcome assessment tools and follow-up duration.
3. Small sample sizes in most included studies, limiting statistical power.
4. Lack of randomized controlled trials in some comparisons.
5. Most studies conducted in single-center settings, potentially limiting generalizability.

Recommendations for Future Research:

1. Larger, multicenter randomized controlled trials comparing partial and complete ACL reconstruction.
2. Standardization of diagnostic criteria and outcome assessment tools.
3. Investigation of long-term functional and biomechanical outcomes beyond 5–10 years.
4. Evaluation of patient-reported outcomes and return-to-sport timing.
5. Comparative analysis of graft types and fixation techniques in partial reconstruction.

References:

1. Friel NA, Chu CR. The role of ACL injury in the development of posttraumatic knee osteoarthritis. Clin Sports Med. 2013;32(1):1.
2. Astur DC, Margato GF, Zobiole A, Pires D, Funchal LFZ, Jimenez AE, et al. The incidence of anterior cruciate ligament injury in youth and male soccer athletes: an evaluation of 17,108 players over two consecutive seasons with an age-based sub-analysis. Knee surgery, Sport Traumatol Arthrosc. 2023;31(7):2556–62.
3. Thomas AC, Hubbard-Turner T, Wikstrom EA, Palmieri-Smith RM. Epidemiology of posttraumatic osteoarthritis. J Athl Train. 2017;52(6):491–6.
4. Gagliardi AG, Carry PM, Parikh HB, Traver JL, Howell DR, Albright JC. ACL repair with suture ligament augmentation is associated with a high failure rate among adolescent patients. Am J Sports Med. 2019;47(3):560–6.
5. Montalvo AM, Schneider DK, Webster KE, Yut L, Galloway MT, Heidt Jr RS, et al. Anterior cruciate ligament injury risk in sport: a systematic review and meta-analysis of injury incidence by sex and sport classification. J Athl Train. 2019;54(5):472–82.
6. Hourston GJM, Kankam HKN, McDonnell SM. A systematic review of anterior cruciate ligament primary repair rehabilitation. J Clin Orthop Trauma. 2022;25:101774.
7. Yeo MHX, Seah SJS, Gatot C, Yew A, Lie D. Selective bundle versus complete anterior-cruciate ligament reconstruction: a systematic review and meta-analysis. J

Orthop. 2022;33:124–30.

8. Greiner JJ, Zsidai B, Mattar LT, Rothrauff BB, Musahl V. Anatomy and Biomechanics of the Knee: Current Concepts. Sport Inj. 2025;1817–38.
9. Sato D, Inoue M, Kasahara Y, Hamano H, Suzuki R, Kondo E, et al. Effects of preserving anatomically positioned and adequate remnant ACL tissue in double-bundle ACL reconstruction. Orthop J Sport Med. 2023;11(4):23259671231162388.
10. Mackenzie CEA, Huntington LS, Tulloch S. Suture tape augmentation of anterior cruciate ligament reconstruction increases biomechanical stability: A scoping review of biomechanical, animal, and clinical studies. Arthrosc J Arthrosc Relat Surg. 2022;38(6):2073–89.
11. Batista JP, Chahla J, Dalmau-Pastor M, Maestu R, Kunze KN, Guelfi M. Arthroscopic anterior cruciate ligament repair with and without suture augmentation. J ISAKOS. 2021;6(4):251–6.
12. Dallo I, Chahla J, Mitchell JJ, Pascual-Garrido C, Feagin JA, LaPrade RF. Biologic approaches for the treatment of partial tears of the anterior cruciate ligament: a current concepts review. Orthop J Sport Med. 2017;5(1):2325967116681724.
13. Xie H, Fu Z, Zhong M, Deng Z, Wang C, Sun Y, et al. Effects of remnant preservation in anterior cruciate ligament reconstruction: a systematic review and meta-analysis. Front Surg. 2022;9:952930.
14. Hoogeslag RAG, Brouwer RW, de Vries AJ, Boer BC, Huis in 't Veld R. Efficacy of nonaugmented, static augmented, and dynamic augmented suture repair of the ruptured anterior cruciate ligament: a systematic review of the literature. Am J Sports Med. 2020;48(14):3626–37.
15. Stone A V, Marx S, Conley CW. Management of partial tears of the anterior cruciate ligament: a review of the anatomy, diagnosis, and treatment. JAAOS-Journal Am Acad Orthop Surg. 2021;29(2):60–70.
16. Pujol N, Colombet P, Potel JF, Cucurulo T, Graveleau N, Hulet C, et al. Anterior cruciate ligament reconstruction in partial tear: selective anteromedial bundle reconstruction conserving the posterolateral remnant versus single-bundle anatomic ACL reconstruction: preliminary 1-year results of a prospective randomized study. Orthop Traumatol Surg Res. 2012;98(8):S171–7.
17. Carulli C, Innocenti M, Roselli G, Sirleo L, Matassi F, Innocenti M. Partial rupture of anterior cruciate ligament: preliminary experience of selective reconstruction. J Orthop Traumatol. 2020;21:1–9.
18. Demirağ B, Ermutlu C, Aydemir F, Durak K. A comparison of clinical outcome of augmentation and standard reconstruction techniques for partial anterior cruciate ligament tears. Eklem Hast ve Cerrahisi. 2012;23(3):140–4.
19. Gobbi A, Whyte GP. Long-term outcomes of primary repair of the anterior cruciate ligament combined with biologic healing augmentation to treat incomplete tears. Am J Sports Med. 2018;46(14):3368–77.
20. Berruto M, Gala L, Ferrua P, Uboldi F, Ferrara F, Pasqualotto S, et al. Surgical treatment of partial anterior cruciate ligament lesions: medium-term results. Joints. 2015;2(4):175.
21. Noyes FR, Huser LE, Levy MS. Rotational knee instability in ACL-deficient knees: role of the anterolateral ligament and iliotibial band as defined by tibiofemoral compartment translations and rotations. JBJS. 2017;99(4):305–14.
22. Bosco F, Giustra F, Crivellaro M, Via RG, Lavia AD, Capella M, et al. Is augmentation the best solution in partial anterior cruciate ligament tears? A literature systematic review and meta-analysis. J Orthop. 2023;36:11–7.