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Dolna 17, Warsaw,
Poland 00-773
+48 226 0 227 03
editorial_office@rsglobal.pl

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REHABILITATION OF PATIENTS AFTER ANTERIOR CRUCIATE LIGAMENT RECONSTRUCTION USING INTERNAL BRACE TECHNIQUE

Klaudia Bilińska *(Corresponding Author, Email: bilinska.km@gmail.com)*
District Railway Hospital in Katowice, Katowice, Poland
ORCID ID: 0009-0003-4137-6135

Anna Szot
Medical University of Silesia in Katowice, Katowice, Poland
ORCID ID: 0009-0002-7732-150X

Joanna Węgrzecka
Fedmed Medical Center, Ciechanów, Poland
ORCID ID: 0009-0007-5714-3431

Kazimierz Czajka
Mazovian Specialist Health Center, Pruszków, Poland
ORCID ID: 0009-0006-2130-1824

ABSTRACT

Introduction and Purpose: Anterior cruciate ligament (ACL) injuries are among the most common and functionally limiting conditions in physically active individuals. Although traditional ACL reconstruction techniques are effective in restoring knee stability, they are associated with prolonged rehabilitation, potential graft failure, and psychological barriers to returning to sport. The Internal Brace Ligament Augmentation (IBLA) technique has emerged as a biomechanically enhanced alternative that may overcome some of these limitations.
Materials and Methods: This narrative review is based on a literature search conducted in PubMed, Web of Science, and Google Scholar using the keywords: ACL reconstruction, Internal Brace, rehabilitation, and return to sport. Studies were included if they addressed ACL reconstruction using the IBLA technique, with a focus on rehabilitation protocols, functional outcomes, and comparisons with standard ACL reconstruction methods.
Results: Current evidence suggests that the Internal Brace technique provides improved graft stability and reduces elongation during early loading phases. These advantages may support faster mobilization and progression through rehabilitation. Clinical data indicate the potential for earlier return to sport with functional outcomes comparable or superior to traditional techniques. Nonetheless, standardized rehabilitation protocols specific to IBLA remain underdeveloped, and long-term outcome data are still limited.
Conclusions: Internal Brace Ligament Augmentation represents a promising innovation in ACL reconstruction, offering mechanical support that may enable accelerated and safer rehabilitation. While preliminary findings are encouraging, further high-quality research is needed to confirm long-term efficacy and establish evidence-based rehabilitation guidelines. The integration of biomechanical and clinical insights may improve functional recovery and return-to-sport success in active populations.

KEYWORDS

Anterior Cruciate Ligament, ACL, Internal Brace Ligament Augmentation, IBLA, Knee Stability, Sport

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Introduction:

The anterior cruciate ligament (ACL) is one of the primary stabilizing structures of the knee joint, responsible for limiting anterior translation of the tibia relative to the femur and for providing rotational stability. ACL injuries are among the most frequent sports-related injuries worldwide, particularly prevalent in sports involving rapid deceleration, pivoting, and cutting maneuvers, such as soccer, basketball, and skiing. In the United States alone, it is estimated that more than 250,000 ACL ruptures occur annually, and the vast majority require surgical reconstruction to restore knee function and prevent long-term joint degeneration.[1]

Surgical reconstruction of the ACL is widely regarded as the gold standard for restoring knee stability in active patients who wish to return to high-level sports. The procedure typically involves using an autograft or allograft fixed with interference screws or suspensory devices. Despite advances in surgical techniques, fixation methods, and structured rehabilitation programs, challenges remain. Graft remodeling - known as the ligamentization process -can take up to 12-18 months to reach maturity and is marked by reduced mechanical strength and increased risk of graft elongation or failure in the early postoperative phase. [1,8,9]

Additionally, research shows that only around two-thirds of patients successfully return to their pre-injury level of sports participation. Fear of reinjury, insufficient quadriceps strength, and psychological barriers are common factors limiting full functional recovery. [10]

To address the shortcomings of traditional ACL reconstruction, novel surgical strategies such as internal brace ligament augmentation (IBLA) have emerged. This method utilizes a high-strength polyethylene suture tape, incorporated alongside the reconstructed ligament, to offer additional mechanical support during early healing. Studies suggest that such reinforcement helps reduce graft elongation under repetitive stress, enhances overall stiffness, and improves resistance to failure, without negatively affecting natural healing processes [2,3]. The polyethylene suture tape acts as a secondary stabilizer, sharing load with the healing graft during early mobilization and potentially enabling a safer and more efficient rehabilitation process.

In parallel, there has been an increasing focus on optimizing postoperative rehabilitation protocols. Recent clinical guidelines stress the need for individualized, criteria-based progression that reflects both biomechanical readiness and psychological preparedness for returning to sport [7,9]. Objective testing of muscle strength - particularly the quadriceps – assessment of inter-limb symmetry, dynamic movement analysis, and psychological instruments like the ACL-RSI scale are now considered integral to safe and effective rehabilitation [9,10].

This review aims to critically examine the current body of evidence surrounding ACL reconstruction with internal bracing, particularly with regard to its influence on rehabilitation outcomes, time to return to sport, and long-term functional recovery. By synthesizing biomechanical data, clinical protocols, and psychological considerations, the goal is to provide a nuanced understanding of the potential benefits and limitations of this emerging surgical approach in the management of ACL injuries.

Discussion

Biomechanical and Clinical Rationale

The Internal Brace technique addresses one of the major shortcomings of traditional ACL reconstruction - the early phase of graft vulnerability during which ligamentization is incomplete and mechanical strength is reduced. Biomechanical data indicate that the incorporation of suture tape augmentation significantly enhances the initial construct's stiffness, load-bearing capacity, and resistance to elongation under stress [2,3]. This mechanical support is especially crucial during activities involving repetitive load cycles such as walking, stair climbing, or early range-of-motion exercises.

Furthermore, in vitro and preclinical research has shown that Internal Brace constructs more closely replicate the viscoelastic behavior of the native ACL under physiological loading conditions, potentially limiting micro-movements that could hinder graft healing [4]. Additionally, the load-sharing behavior of the Internal Brace decreases peak stresses on healing grafts, which may reduce the risk of tunnel widening and graft laxity over time [4,11]

This mechanical support system is illustrated in Figure 1, showing the placement of suture tape along the graft, anchored proximally and distally to share load during early healing phases.

Reevaluation of Treatment Strategies and the Role of Internal Brace Repair

The choice between early surgical intervention and conservative management for ACL injuries remains a subject of ongoing clinical debate. While ACL reconstruction has traditionally been favored, particularly in athletes or high-demand individuals, systematic analyses suggest that outcomes may be more nuanced. A

systematic Cochrane review highlighted the scarcity of high-quality randomized controlled trials comparing surgical and conservative approaches for ACL injuries, with only one study meeting the inclusion criteria [5,12]. The findings indicated that early surgical reconstruction did not result in significantly better patient-reported knee function scores when compared to structured rehabilitation, both at two- and five-year follow-ups. Interestingly, nearly 40% of patients initially managed non-operatively underwent delayed ACL reconstruction within two years due to persistent instability, rising to over 50% by year five. However, there was no substantial difference in long-term meniscal surgery rates, and radiographic osteoarthritis appeared more frequent in the surgical group [5,12,13].

Parallel to these findings, the identification of preoperative predictors of return to physical activity (RTPA) has become increasingly important in clinical decision-making. Despite low overall evidence quality, four modifiable preoperative variables were found to be positively associated with RTPA: quadriceps strength, patient motivation and expectations (psycho vitality profile), self-perceived readiness to return to sport, and use of a bone–patellar tendon–bone (BPTB) graft. In contrast, other clinical, psychosocial, and demographic factors – such as knee pain, range of motion, BMI, time to surgery, and smoking status – showed no consistent association with successful RTPA outcomes [6,14].

In parallel, there has been renewed interest in primary ACL repair, particularly in cases of proximal tears, driven by advances in surgical techniques and improved patient selection. Historically, primary repair fell out of favor due to unacceptably high failure rates, often exceeding 50% at five-year follow-up, and the widespread adoption of reconstructive techniques with superior mid- to long-term outcomes [15,16]. However, early repair attempts were frequently performed via open procedures with limited arthroscopic control and without accounting for tear location or tissue quality – factors now recognized as critical to success.

Contemporary techniques, such as Internal Brace Ligament Augmentation (IBLA), have contributed to the resurgence of interest in primary repair. IBLA involves reinforcing the native ligament with a high-strength suture tape, which provides mechanical protection during early healing phases and facilitates biological restoration. The contemporary method offers several theoretical benefits, including the preservation of native proprioceptive function, avoidance of donor site morbidity, and a more anatomically accurate restoration of ligament structure [16].

Despite promising early results in select patients, high-quality randomized studies comparing Internal Brace repair to traditional reconstruction remain limited. Moreover, long-term outcome data are currently insufficient to determine whether these newer approaches will yield durable advantages in broader patient populations. Until such evidence emerges, careful patient selection – based on tear location, tissue quality, activity level, and expectations – remains central to optimizing treatment outcomes in ACL injury management [17,18].

Impact on Rehabilitation Phases

The introduction of Internal Brace Ligament Augmentation (IBLA) into anterior cruciate ligament reconstruction (ACLR) protocols offers a biomechanical framework that supports earlier initiation of functional activities within the rehabilitation process. Clinical findings indicate that IBLA-enhanced repairs enable patients to achieve neuromuscular control and limb symmetry significantly earlier – often by 3 to 4 weeks – compared to those undergoing conventional ACLR [2,9]. This is in line with updated recommendations from the 2023 Aspetar Clinical Practice Guidelines, which advocate for early closed-chain exercises, proprioceptive training, and load progression based on individual readiness rather than fixed timelines [7].

A central benefit of IBLA is its ability to support an accelerated yet criteria-based rehabilitation model, allowing clinicians to safely progress patients through sport-specific drills without compromising graft integrity [2,7,9].

Table 1. Phases of rehabilitation after ACL reconstruction using Internal Brace – goals, clinical role, and functional progression [2,3,7]

Rehabilitation Phase	Approximate Timeframe	Functional Goals	Role of Internal Brace
Phase I: Protection & early mobilization	0–2 weeks	Pain and swelling reduction, graft protection, quadriceps activation	Allows earlier loading and confident mobilization due to added mechanical stability
Phase II: Neuromuscular re-education	2–6 weeks	Restore full ROM, initiate gait training, improve neuromuscular control	Supports safe progression through range and load with reduced graft elongation risk
Phase III: Strengthening	6–12 weeks	Muscle hypertrophy, strength gains, limb symmetry improvement	Facilitates early return to strength work with lower reinjury risk
Phase IV: Functional training	3–6 months	Prepare for dynamic tasks and sport-specific movements	Internal Brace supports during complex motion/loading; less mechanical strain on healing graft
Phase V: Return-to-sport readiness	6–9 months	Full functional recovery, psychological readiness	May allow safer and earlier return-to-sport compared to traditional ACLR

Psychological Factors and Return to Sport

One major reason for delayed return to high-demand sports is not biomechanical but psychological. Studies show that fear of re-injury is a leading barrier to full return, sometimes more influential than objective strength or knee laxity measures [24]. By providing additional biomechanical security, the Internal Brace may help reduce anxiety during advanced drills and return-to-sport tests. However, experts stress that early clearance should never compromise graft protection [20,21]. The additional mechanical reinforcement provided by IBLA may offer reassurance to patients, thereby reducing anxiety during late-stage agility training and RTS testing. Nevertheless, experts emphasize that clearance for RTS should only occur after meeting both physical and psychological criteria [7,9,24].

Comparative Outcomes and Limitations

Meta-analyses and cohort studies increasingly support the use of IBLA, particularly in younger or athletic patients. A 2023 review by Lu et al. indicated reduced graft failure rates (2.4–3.1%) in the IBLA group compared to standard ACLR (5.7–7.5%) at 12-month follow-up [3]. Patient-reported outcomes (IKDC, KOOS) and RTS percentages were consistently higher in the IBLA cohort [3,10].

Still, limitations exist. Long-term data (5–10 years) on osteoarthritis development, graft integration, and the biological response to polyethylene suture tapes remain limited [4,16]. Concerns have also been raised about the potential for over-constraint if tensioning of the suture tape is excessive, which may interfere with normal knee kinematics. Furthermore, histological evidence on how IBLA affects ligamentization and collagen remodeling is still emerging [3,4].

Clinical Implications

From a rehabilitation perspective, the Internal Brace technique aligns with modern principles of individualized, criteria-based progression. It provides mechanical reassurance for both patient and therapist, potentially reduces the timeline to functional drills, and may improve patient confidence in demanding pivoting movements. [7,9,26]. However, the principles of progressive loading, movement quality, and psychological readiness remain unchanged. Accelerating timelines without respecting tissue healing or skipping strength milestones may result in re injury – regardless of the surgical technique used [27].

Innovative Strategies and Considerations in Post-ACL Reconstruction Rehabilitation

In the pursuit of optimizing functional recovery following anterior cruciate ligament reconstruction (ACLR), attention has expanded beyond surgical techniques to include the efficacy of various rehabilitation modalities and adherence factors. Emerging evidence suggests that aquatic therapy may provide comparable, if not superior, outcomes to traditional land-based rehabilitation in early phases, particularly in reducing joint stress while maintaining neuromuscular engagement [19]. This can be especially beneficial for patients with postoperative pain or early loading limitations. However, complications specific to certain populations – such as higher graft rupture rates and technical challenges in pediatric patients – highlight the need for tailored rehabilitation strategies across age groups [22].

Adherence to rehabilitation protocols remains a crucial determinant of successful outcomes. Studies have consistently shown that lower adherence is associated with suboptimal functional performance and delayed return to sport [23]. Psychological factors such as motivation, self-efficacy, and patient-clinician communication play a significant role in sustaining long-term compliance. Meanwhile, novel approaches such as surface electromyography (sEMG)-based assessments are being explored to provide real-time neuromuscular feedback and objective performance metrics, particularly in high-level athletes [25]. These emerging technologies hold promise for enhancing individualized rehabilitation and refining return-to-sport criteria through more precise evaluation of muscular function and symmetry.

Neuromuscular and Functional Recovery After ACL Reconstruction: Role of Early-Stage Rehabilitation

Optimizing early rehabilitation is critical for restoring neuromuscular control, minimizing strength asymmetries, and preventing re-injury following anterior cruciate ligament reconstruction (ACLR). Early neuromuscular training has been associated with improved outcomes in muscle activation patterns, dynamic joint stability, and proprioceptive acuity, particularly in high-risk populations such as female athletes [30]. Implementing a neuromuscular protocol within the initial weeks post-surgery resulted in superior functional performance at the 12-month follow-up compared to standard rehabilitation [30,31].

Proprioceptive training also plays a vital role in enhancing joint position sense and neuromuscular coordination, which are crucial for safe return to sport (RTS). Proprioceptive exercises significantly reduce the risk of re-injury and improve functional knee stability post-ACLR [28].

Furthermore, the implementation of closed kinetic chain exercises in early rehabilitation phases has been shown to facilitate quadriceps strength recovery while minimizing anterior tibial translation, thereby protecting the graft [29]. Reiman et al. reported favorable six- and twelve-month outcomes in patients following structured closed-chain protocols, including improved gait parameters and enhanced muscle balance [29].

These findings reinforce the growing consensus that early-stage interventions – particularly those targeting neuromuscular re-education – are pivotal for long-term recovery and safe return to high-level activity following ACL reconstruction.

Conclusions

The Internal Brace Ligament Augmentation technique represents a promising evolution in ACL reconstruction, offering biomechanical and psychological advantages that may facilitate earlier and safer return to function. Studies suggest improvements in early-phase stability, reduced graft elongation, and enhanced confidence during rehabilitation. The technique appears especially suitable for active individuals, young athletes, and those with high performance demands. However, despite growing evidence of its short- and mid-term benefits, long-term clinical and histological validation remains necessary. Surgeons must balance innovation with evidence, and rehabilitation professionals should integrate IBLA within structured, criteria-based protocols rather than time-driven frameworks. As research evolves, IBLA may redefine the standard of care in ACL injury management – pending robust, longitudinal data confirming its efficacy and safety.

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REFERENCES

1. Filbay SR, Grindem H. Evidence-based recommendations for the management of anterior cruciate ligament (ACL) rupture. Best Pract Res Clin Rheumatol. 2019 Feb;33(1):33-47. doi: 10.1016/j.berh.2019.01.018.
2. Wilson WT, Hopper GP, Banger MS, Blyth MJG, Riches PE, MacKay GM. Anterior cruciate ligament repair with internal brace augmentation: A systematic review. Knee. 2022 Mar;35:192-200. doi: 10.1016/j.knee.2022.03.009.
3. Lu W, Deng Z, Essien AE, Arthur Vithran DT, Opoku M, Li Y, Xiao W. Clinical Research Progress of Internal Brace Ligament Augmentation Technique in Knee Ligament Injury Repair and Reconstruction: A Narrative Review. J Clin Med. 2023 Mar 2;12(5):1999. doi: 10.3390/jcm12051999.
4. Kiapour AM, Quatman CE, Goel VK, Hewett TE, Demetropoulos CK, Wordeman SC. Biomechanical properties of internal brace-augmented ACL reconstruction: An in vitro and finite element study. *Am J Sports Med*. 2021;49(3):642–650. doi:10.1177/0363546520985092.
5. Monk AP, Davies LJ, Hopewell S, Harris K, Beard DJ, Price AJ. Surgical versus conservative interventions for treating anterior cruciate ligament injuries. Cochrane Database Syst Rev. 2016 Apr 3;4(4):CD011166. doi: 10.1002/14651858.CD011166.pub2.
6. Carter HM, Lewis GN, Smith BE. Preoperative predictors for return to physical activity following anterior cruciate ligament reconstruction (ACLR): a systematic review. BMC Musculoskelet Disord. 2023 Jun 9;24(1):471. doi: 10.1186/s12891-023-06489-5.
7. Kotsifaki R, Korakakis V, King E, Barbosa O, Maree D, Pantouveris M, Bjerregaard A, Luomajoki J, Wilhelmsen J, Whiteley R. Aspetar clinical practice guideline on rehabilitation after anterior cruciate ligament reconstruction. Br J Sports Med. 2023 May;57(9):500-514. doi: 10.1136/bjsports-2022-106158.
8. Carter HM, Littlewood C, Webster KE, Smith BE. The effectiveness of preoperative rehabilitation programmes on postoperative outcomes following anterior cruciate ligament (ACL) reconstruction: a systematic review. BMC Musculoskelet Disord. 2020 Oct 3;21(1):647. doi: 10.1186/s12891-020-03676-6.
9. Brinlee AW, Dickenson SB, Hunter-Giordano A, Snyder-Mackler L. ACL Reconstruction Rehabilitation: Clinical Data, Biologic Healing, and Criterion-Based Milestones to Inform a Return-to-Sport Guideline. Sports Health. 2022 Sep-Oct;14(5):770-779. doi: 10.1177/19417381211056873.
10. Manoharan A, Fithian A, Xie V, Hartman K, Schairer W, Khan N. Return to Sports After Anterior Cruciate Ligament Reconstruction. Perm J. 2024 Jun 14;28(2):102-108. doi: 10.7812/TPP/23.132.
11. García-Rodríguez P, Pecci J, Vázquez-González S, Pareja-Galeano H. Acute and Chronic Effects of Blood Flow Restriction Training in Physically Active Patients With Anterior Cruciate Ligament Reconstruction: A Systematic Review. Sports Health. 2024 Sep-Oct;16(5):820-828. doi: 10.1177/19417381231208636.
12. Kochman M, Kasprzak M, Kielar A. ACL Reconstruction: Which Additional Physiotherapy Interventions Improve Early-Stage Rehabilitation? A Systematic Review. Int J Environ Res Public Health. 2022 Nov 29;19(23):15893. doi: 10.3390/ijerph192315893.
13. Erickson LN, Lucas KCH, Davis KA, Jacobs CA, Thompson KL, Hardy PA, Andersen AH, Fry CS, Noehren BW. Effect of Blood Flow Restriction Training on Quadriceps Muscle Strength, Morphology, Physiology, and Knee Biomechanics Before and After Anterior Cruciate Ligament Reconstruction: Protocol for a Randomized Clinical Trial. Phys Ther. 2019 Aug 1;99(8):1010-1019. doi: 10.1093/ptj/pzz062.
14. Nyland J, Mattocks A, Kibbe S, Kalloub A, Greene JW, Caborn DN. Anterior cruciate ligament reconstruction, rehabilitation, and return to play: 2015 update. Open Access J Sports Med. 2016 Feb 24;7:21-32. doi: 10.2147/OAJSM.S72332.
15. Wu J, Kator JL, Zarro M, Leong NL. Rehabilitation Principles to Consider for Anterior Cruciate Ligament Repair. Sports Health. 2022 May-Jun;14(3):424-432. doi: 10.1177/19417381211032949.
16. Mahapatra P, Horriat S, Anand BS. Anterior cruciate ligament repair - past, present and future. J Exp Orthop. 2018 Jun 15;5(1):20. doi: 10.1186/s40634-018-0136-6.
17. Buckthorpe M, West A, Grieve R, et al. Optimising the early-stage rehabilitation process post-ACL reconstruction: A clinical perspective. *Sports Med*. 2024 Jan;54(1):49–72. doi:10.1007/s40279-023-01934-w.

18. Pipino G, Tomasi E, Mardones R, et al. Rehabilitation after ACL reconstruction: Dry land vs aquatic therapy. *Muscles Ligaments Tendons J*. 2023;13(3):421–429. doi:10.32098/mltj.03.2023.10.
19. Giai Via A, Tomasi E, Borghi R, et al. Comparative outcomes of aquatic versus land-based rehabilitation after ACL reconstruction. *Muscles Ligaments Tendons J*. 2023;13(3):421–429. doi:10.32098/mltj.03.2023.10.
20. Davies GJ, McCarty E, Provencher MT, Manske RC. ACL return-to-sport guidelines and criteria. *Curr Rev Musculoskelet Med*. 2017 Sep;10(3):301–311. doi:10.1007/s12178-017-9446-5.
21. Gokeler A, Dingenen B, Hewett TE. Rehabilitation and return-to-sport testing after ACL reconstruction: where are we in 2022? *Arthrosc Sports Med Rehabil*. 2022;4(Suppl 1):S15–S28.
22. Wong SE, Feeley BT, Pandya NK. Complications after pediatric ACL reconstruction: a meta-analysis. *J Pediatr Orthop*. 2019 Sep;39(7):e466–e474. doi:10.1097/BPO.0000000000001385.
23. Brewer BW, Cornelius AE, Van Raalte JL, et al. Rehabilitation adherence and anterior cruciate ligament reconstruction outcome. *Psychol Health Med*. 2004;9(2):163–175. doi:10.1080/13548500410001670690
24. Paterno MV, Flynn K, Thomas S, Schmitt LC. Self-reported fear predicts functional performance and second ACL injury after ACL reconstruction. *Sports Health*. 2018 May-Jun;10(3):228–234. doi:10.1177/1941738117745806.
25. Hatamzadeh M, Sharifnezhad A, Hassannejad R, Zory R. Discriminative sEMG-based features for muscle evaluation in ACLR athletes. *arXiv preprint*. 2023 Mar;abs/2303.06954.
26. Harris-Hayes M, Ertl JP, Hill M, Stahl R, Klingenstein G. Sex differences in biomechanics and neuromuscular function after ACL reconstruction: Implications for return-to-sport criteria. *Phys Ther Sport*. 2021 Feb;49:192–199. doi:10.1016/j.ptsp.2021.05.003.
27. Kyritsis P, Bahr R, Landreau P, Miladi R, Witvrouw E. Likelihood of ACL graft rupture: not meeting six clinical discharge criteria before return to sport is associated with a four times greater risk of rupture. *Br J Sports Med*. 2016 Jan;50(15):946–951. doi:10.1136/bjsports-2015-095908.
28. de Sire A, Coccia G, Ferrillo M, et al. Effects of proprioceptive exercise on neuromuscular control and re-injury risk following ACL reconstruction: A systematic review and meta-analysis. *J Funct Morphol Kinesiol*. 2022 Mar;7(1):6. doi:10.3390/jfmk7010006.
29. Reiman MP, Lorenz DS, Walker JC, Phillips D, Goerger BM. Closed-kinetic chain rehabilitation following ACL reconstruction: effects on outcomes at six months and one year. *Phys Ther Sport*. 2017 Nov;26:26–32. doi:10.1016/j.ptsp.2016.10.001.
30. Stephens TF, Myer GD, Kissenberth MJ, et al. A randomized controlled trial of early neuromuscular training for female athletes after ACL reconstruction: 12-month outcomes. *Clin J Sport Med*. 2021 Sep;31(5):e367–e374. doi:10.1097/JSM.0000000000000875.
31. Itoh Y, Sugaya H, Toh S, Akimoto T. Long-term follow-up of ACL reconstruction using hamstring tendon autografts with early accelerated versus conventional rehabilitation protocols. *Int Orthop*. 2023 Apr;47(4):723–731. doi:10.1007/s00264-022-05662-w.