Type of the Paper (Article)

Functional outcomes after anterior cruciate ligament reconstruction using adjustable femoral cortical suspensory fixation device: Systemic review and Meta analysis

Ahmed M. Abdulwahab[1*], Mohamed S. Arafa[2], Hatem A. Kotb[2], Mohamed S. El Azab[2]

[1]Orthopedic Surgery Department, Faculty of Medicine, Alexandria University, Alexandria, Egypt.

[2]Orthopedic Surgery Department, Faculty of Medicine, Fayoum University, 63514 Fayoum, Egypt

*Correspondence: Ahmed M. Abdulwahab, ahmedawh@gmail.com; Tel.:(002) 01005591038.

Received: 21 November, 2023 Reviewed: 28 November, 2023
Accepted: 1 January, 2024 Published online: 8 April, 2024

Abstract:

Introduction: The anterior cruciate ligament (ACL) injury is considered the most common ligamentous injury in the knee, and its reconstruction is essential for overall knee stability. Adequate graft fixation is essential to facilitate a rehabilitation program that strives for early restoration of knee mobility & strength after ACL reconstruction (ACLR) with all soft tissue grafts.

Aim of the study: This research evaluates the functional outcomes of ACLR performed using an adjustable femoral cortical suspensory fixation device.

Methods: To find publications contrasting full tibial tunnel ACLR with an all-inside technique employing an adjustable femoral cortical suspensory fixation device, we searched PubMed, Embase, and Cochrane. Eligibility, data extraction, and risk of bias were all performed on potentially relevant papers by two reviewers who were blind to each other's work. Random effects with mean variations as well as risk ratios for continuous, in addition to dichotomous factors, were aggregated for the clinical outcome along with graft ruptures.

Results: The meta-analysis includes 10 research studies with a total of 613 individuals. Participants who underwent all-inside ACLR with an adjustable femoral cortical suspensory fixation device or full tibial tunnel ACLR had similar functional outcomes, knee laxity as determined by the arthrometer, and graft rupture rates.

Conclusions: Based on this systematic review, we can conclude that using the adjustable suspensory fixation device for ACLR produces favorable functional outcomes as regards knee stability and mobility.

Keywords: ACL reconstruction; fixed-loop device; adjustable-loop device.

1. Introduction

A stable graft fixation is essential for a rehabilitation program that aims for early restoration of knee mobility as well as strength after ACLR with all soft tissue grafts. The goal of this reconstruction is to help the patient return to normal knee motion and stability as soon as possible. Throughout the past few years, the employment of suspensory fixation as an alternative to interference screws has become an increasingly appealing choice. This is because it has the potential to speed up tendon-to-bone healing [1, 2], and it also protects the graft from harm caused by the insertion of screws [3, 4].

When contrasted with extra-cortical fixation, the application of interference screws contributed to a considerable initial development of the bone tunnel at the time of the operation. This led to larger bone tunnels after two years, as opposed to the use of extra-cortical fixation. Moreover, the use of interference screws led to a major early development of the bone tunnel at the time of the procedure [5, 6]. This occurs when compared to extra-cortical fixation because interference screws are inserted through the bone rather than through the extra-cortical space. When utilizing interference screws for graft fixation, screw divergence is another technical concern that may contribute to a loss of pullout strength [7, 8].

A fixed-loop device (FLD) was used to secure the graft to a metallic button in the initial generation of suspensory devices. There are some pitfalls associated with FLD fixation, even though it offers great stability and a high level of fixation strength [9, 10]. Since the length of the loop is predetermined, FLD necessitates precise measurement throughout the tunnel construction process. After the graft has been tensioned, there will be a cavity above the graft since the femoral socket was drilled 6–8 mm longer than necessary to allow for the "flip" movement of the button. This method could potentially contribute to the so-called “bungee cord effect” as well as the windshield wiper effect, which would result in an increased likelihood of tunnel widening (TW) [11].

The second generation of suspensory devices is known as an adjustable-loop device (ALD). It has a locking mechanism that can only be locked in one direction. The length of the device is maintained by the friction between the sutures. The use of ALD makes it easier to control the graft tension & to re-tension it after passive cycling of the knee is performed. In addition to this, improved filling of the bone tunnels is conceivable, which will result in a decreased amount of dead space [11, 12]. However, according to the findings of biomechanical research, ALD has the potential to stretch during cyclic loading, which can lead to laxity in the graft. Re-tensioning the ALD build and tying knots in it could help minimize the severity of this problem [13, 14].

2. Methods

2.1.Literature search

The results of the online search came to a total of 2937 references. Following the removal of 837 duplicates, the screening of titles and abstracts continued with 2100 records. We had a total of 30 suitable articles for full-text screening, but only 10 of them met the requirements to be included, while the remaining 20 were disqualified. There were no additional articles imported as a result of the manual search of references. In the end, a total of 10 studies were incorporated into the qualitative analysis.

2.2.Study characteristics

Details for the involved studies are summarized in Table 1.

Table1: The Study characteristics.

Reference	Type of Study	No.	Age	M/F	Injury-surgery, time	ACL rupture type	Graft diameter	The side-to-side difference in anterior laxity	Post at last follow-up
[16]	Prospective	75	29.7	50/25	0.5			3.4 ± 3.0	2.2 ± 2.0
[17]	Cohort	36	27.5	24/12	3.8				
[18]	RCT	15	25.7	8/7					
[19]	Prospective	30	26.8	27/3	4.7				
[20]	Prospective	94	28.4	60/34					
[21]	Prospective	30	26.9						
[22]	Prospective	38	31.2	29/9	5.25		8.4 (0.5)		
[23]	Prospective	50	30.4	40/10	4.4				
[24]	Case-control	97	30.9	64/33	26.4	53/44	8.8	3.1 (2)	0.8 (1.8)
[25]	Retrospective	50	28.2	41/9					

2.3.Risk of Bias Within Studies

For the RCTs, we used the Risk of Bias 2.0 tool developed by the Cochrane Collaboration to evaluate the potential for bias resulting from the randomization method, missing outcome data, deviation from intended interventions, measuring the result, as well as the selection of reported results. In the quasi-experimental research, the RoBINS-I tool was applied to assess bias caused by confounding factors in the classification of interventions, the selection of participants, missing outcome data, deviation from intended interventions, the measuring of outcomes, as well as the selection of reported results. All studies showed either low or unclear risk across different parameters, with an overall moderate to high quality.

Inclusion criteria

Randomized and non-randomized controlled trials published in the last 5 years: evaluation of Functional Results after Anterior Cruciate Ligament Reconstruction Using an Adjustable Femoral Cortical Suspensory Fixation Device.

Exclusion criteria

Articles that were originally published in languages other than English. Evaluations, guiding principles, categorizations, case reports, briefcase series, or conference papers are all excluded.

2.4.Statistical analysis

Using the mean & standard deviation, we aggregated data on continuous outcomes. When just a range was given, the expected standard deviation was determined by using range/4 for small to medium-sized samples (15–70 n) and range/6 for large samples (n > 70). The extracted results were merged, and the chi-squared test with Fisher's correction was used to objectively evaluate IKDC scores. Standardized mean variances (SMDs) of extracted data suggested better treatment options. We synthesized dichotomous outcome data using OR. Standardized mean variances and ORs were pooled using a random-effects model. For each outcome, a 95% CI was determined. The I2 test revealed between-trial heterogeneity, with values >50% indicating significant heterogeneity. Everything was analyzed using a comprehensive meta-analysis (Version 3.3.070).

3. Results

The meta-analysis results are shown in **Table 2.**

Table 2: The study outcomes.

Ref	IKDC subjective score		KOOS	Lysholm score		Tegner score		KT-1000 Measurement		Pivot shift test (negative/ positive)
	Pre	Post	Post	Pre	Post	pre	post	pre	post	
[16]				63.2± 4.3	92.8± 6.9			10.6± 3.5	10.2± 2.2	18/76
[17]	48.8 (13.3%)		90.7 (9.3%)		87.3± 12.1		5.5± 1.7			
[18]				71.6± 19.3	86.7± 13.3					
[19]		88.327± 7.303			94± 5.527					30/0
[20]										
[21]				55.20± 9.22	92.97± 9.02					
[22]	39.6 (6.9%)	88.7 (5.3%)		61.2 (8.6%)	91.0 (6.5%)	3.1 (1.1%)	5.5 (2.1%)			30/8
[23]	38.5	38.5			52					
[24]	60.4 (15%)	87.6 (10.6%)		75.6 (13%)	90.8 (9.3%)		6.6 (2%)			
[25]				58.1± 16	94.3± 6.8	2.3± 0.9	5.8± 1.7			

4. Discussion

The initial mechanical qualities of the graft, the position of the femoral as well as tibial tunnel, the fixation method, and the postoperative rehabilitation all have a role in whether or not ACLR is successful [26, 27]. The stability of the knee joint depends on several factors, not the least of which is the graft's initial fixation as well as subsequent absorption into the tunnels. Because of its ease of use, dependability, and superior tensile strength, cortical suspensory fixation using titanium button devices has become increasingly used in ACLR with soft-tissue grafts [28–30]

However, in anatomical ACLR using the anteromedial portal technique, deployment of cortical suspensory fixation devices with permanent loops like the EndoButton (EB) may be unsuccessful if the graft tunnel is too short to allow clearance of the device through the femur. Over-drilling the tunnel, which requires precise tunnel measuring, can increase the likelihood of graft motion in the tunnel [31, 32].

TightRope (TR) and other second-generation suspensory fixation devices with an adjustable loop were designed to address the shortcomings of fixed-loop fixation devices. It is hypothesized that the hamstring graft would lessen the "bungee cord effect," hence minimizing tunnel widening, because the device utilizes a number of sutures that can be employed as a pulley system to shorten the loop and transport the graft to the end of the femoral socket for a snug fit. Although various biomechanical studies have demonstrated that ALD ultimately results in longer limbs than FLD, data on clinical effects is scant [33, 34].

Regarding outcomes, in our systematic review, there were improvements in Lysholm's knee score & IKDC scores [16, 18, 19, 21, 22, 24, 25]. Sharma et al. (2018) determined that both the FLD and ALD have the potential to offer secure fixation, an equal reduction of graft laxity, and comparable functional consequences in ACL-deficient knees following ACL graft femoral fixation [10].

In 2018, a controlled trial conducted by de Sa et al. noticed that the all-inside ACLR approach had a minimal graft failure rate as well as optimal clinical improvement [34]. Instead of comparing various surgical techniques, this review compiled the results of individual investigations. Browning et al. (2017) revealed that the suspensory fixation device led to greater stabilization of the knee & lower graft failure rates in a systematic review of ACLR with either suspensory or aperture fixation [35].

As surgical tools & methods have advanced, suspensory devices have become standard in all-in-one ACLRs. Therefore, the clinical result of ACLR may be influenced by both the bone tunnel preparation process and the fixation device. In most cases, just the semitendinosus tendon needs to be harvested to achieve the length required for suspensory cortical button fixation [36].

This smaller limit diameter is also possible through the application of a quadrupled semitendinosus tendon graft in most cases; this has been thought of as a fundamental characteristic of the all-inside ACLR with the suspensory cortical button fixation technique. Previous systematic reviews concluded that ACLRs with a tendon graft thickness of 8 mm had lower failure rates [37]. However, several factors, including gender, age, and body height, may affect the thickness of the tendon graft. Therefore, it is important to keep in mind that the Semitendinosus tendon alone is not sufficient for each individual to attain the optimal graft size and thickness, and the Gracilis must be harvested as a secondary source.

Hardik et al. (2017) evaluated the effectiveness of arthroscopic ACLR done with a fixed suspensory device compared to that of an adjustable suspensory device for femoral side graft attachment in a study that was prospective and included 62 patients with knees that lacked an ACL [38]. Before and after surgery, the Lysholm score and the IKDC score were utilized to evaluate the functional status. Following the procedure, the Lysholm score was 94.23% in the fixed-loop group, and it was 94.32% in the adjustable-loop group. The fixed-loop group and the adjustable-loop group both achieved a score of 92.03% on the IKDC, with the latter group achieving a score of 92.16%.

Conclusion

Based on this systematic review, we can conclude that using the adjustable suspensory fixation device for ACLR produces favorable functional outcomes as regards knee stability and mobility.

Funding: This study is not funded.

Conflicts of Interest: All authors declare they have no conflicts of interest.

References

1. Hashem AM, Soliman HM, Abdelhalim KM, Rashwan AS, Soliman AA. A Study Comparing the Effectiveness of Hamstring Tendon Graft Versus Quadriceps Tendon Graft in Press Fit Anterior Cruciate Ligament Reconstruction. Journal of Advanced Zoology. 2023;44(S-3):50-62.
2. Chahla J, Dean CS, Cram TR, Civitarese D, O'Brien L, Moulton SG, LaPrade RF. Two-stage revision anterior cruciate ligament reconstruction: bone grafting technique using an allograft bone matrix. Arthroscopy Techniques. 2016;5(1):e189-95.
3. Bosco F, Giustra F, Ghirri A, Cacciola G, Massè A, Capella M. All-Inside Anterior Cruciate Ligament Reconstruction Technique: Tips and Tricks. Journal of Clinical Medicine. 2023;12(18):5793.
4. Diermeier T, Tisherman R, Hughes J, Tulman M, Baum Coffey E, Fink C, Lynch A, Fu FH, Musahl V. Quadriceps tendon anterior cruciate ligament reconstruction. Knee Surgery, Sports Traumatology, Arthroscopy. 2020;28:2644-2656.
5. Solomon R, Hommen JP, Travascio F. Effects of Platelet-Rich Osteoconductive–Osteoinductive Allograft Compound on Tunnel Widening of ACL Reconstruction: A Randomized Blind Analysis Study. Pathophysiology. 2022;29(3):394-404.
6. D’Ambrosi R, Meena A, Arora ES, Attri M, Schäfer L, Migliorini F. Reconstruction of the anterior cruciate ligament: a historical view. Annals of Translational Medicine. 2023;11(10).
7. Smith A, Noyes FR. What is the scientific basis for knee ligament healing and maturation to restore biomechanical properties and a return to sport? In: Noyes FR, Barber-Westin S (eds). Return to sport after ACL reconstruction and other knee operations: limiting

the risk of reinjury and maximizing athletic performance. Springer; 2019, pp. 121-55.

8. Farouk H, Ben-Ziad T. Bone plug fixation in anterior cruciate ligament reconstruction: A clinical and radiological assessment of graft-tunnel integration. The Knee. 2022;37:153-161.
9. Pandey SK, Khare R, Yadav AK, Deswal D, Jaiswal S. Functional outcome of arthroscopic anterior cruciate ligament reconstruction using variable loop cortical suspensory fixation. Journal of Bone and Joint Diseases. 2022;37(2):70-75.
10. Sharma B, Parmar RS. Early outcome analysis of arthroscopic anterior cruciate ligament reconstruction using fixed closed loop and adjustable loop techniques: A prospective case series. Journal of Orthopaedics and Allied Sciences. 2018;6(2):74.
11. Colombet P, Saffarini M, Bouguennec N. Clinical and functional outcomes of anterior cruciate ligament reconstruction at a minimum of 2 years using adjustable suspensory fixation in both the femur and tibia: a prospective study. Orthopedic journal of sports medicine. 2018;6(10):2325967118804128.
12. Gamboa JT, Shin EC, Pathare NP, McGahan PJ, Chen JL. Graft re-tensioning technique using an adjustable-loop fixation device in arthroscopic anterior cruciate ligament reconstruction. Arthroscopy techniques. 2018;7(2):e185-191.
13. Smith PA, Cook CS. Knotless primary anterior cruciate ligament repair with adjustable loop device and internal brace augmentation. Arthroscopy Techniques. 2020;9(12):e1967-1975.
14. Born TR, Biercevicz AM, Koruprolu SC, Paller D, Spenciner D, Fadale PD. Biomechanical and computed tomography analysis of adjustable femoral cortical fixation devices for anterior cruciate ligament reconstruction in a cadaveric human knee model. Arthroscopy: The Journal of Arthroscopic & Related Surgery. 2016;32(2):253-261.
15. Mayr R, Heinrichs CH, Eichinger M, Coppola C, Schmoelz W, Attal R. Biomechanical comparison of 2 anterior cruciate ligament graft preparation techniques for tibial fixation: adjustable-length loop cortical button or interference screw. Am J Sports Med. 2015;43(6):1380–1385.
16. Heng CH, Wong JY, Tan AH. Both Adjustable and Fixed Loop Hamstring Tendon Graft Fixation Have Similar Clinical and Patient-Reported Outcomes in Anterior Cruciate Ligament Reconstruction. Arthroscopy, Sports Medicine, and Rehabilitation. 2023;5(5):100775.
17. Schützenberger S, Keller F, Grabner S, Kontic D, Schallmayer D, Komjati M, Fialka C. ACL reconstruction with femoral and tibial adjustable versus fixed-loop suspensory fixation: a retrospective cohort study. Journal of Orthopaedic Surgery and Research. 2022;17(1):1-8.
18. Ono Y, Sato Y, Mukai H, Enomoto T, Kimura S, Nakagawa R, Akagi R, Inaba Y, Kawasaki Y, Ohtori S, Sasho T. Randomized comparative study of suspension femoral fixation device in graft position maintenance in anterior cruciate ligament reconstruction: EndoButton CL vs TightRope RT. Asia-Pacific Journal of Sports Medicine, Arthroscopy, Rehabilitation and Technology. 2021;25:42-46.
19. Djordjević D, Petrović M, Žunčić SD, Stojiljković P, Golubović I, Kadija M, Micić I. Application of two types of suspensory fixation in the reconstruction of the anterior cruciate ligament with a semitendinosus-gracilis graft–A randomized prospective study. Vojnosanitetski pregled. 2021;78(10).
20. 20. Kumar R, Kalra M, Garg AK, Choudhary R, Venishetty N, Verma S, Kumar A, CHOUDHARY R, Kumar Sr A. Clinical Reliability of Adjustable Femoral

Cortical Suspensory Fixation in Anterior Cruciate Ligament Reconstruction and Correlation of Clinical Outcomes with Demographic and Perioperative Factors. Cureus. 2021;13(5).

21. Mohamed RS, El-Shafie MH, El-Sheikh MA. Clinical Outcome of Fixed Versus Adjustable Loop Cortical Suspension Devices in Arthroscopic Anterior Cruciate Ligament Reconstruction. Ortopedia Traumatologia Rehabilitacja. 2020;22(3):181-185.
22. Ahn JH, Ko TS, Lee YS, Jeong HJ, Park JK. Magnetic resonance imaging and clinical results of outside-in anterior cruciate ligament reconstruction: a comparison of fixed-and adjustable-length loop cortical fixation. Clinics in Orthopedic Surgery. 2018;10(2):157.
23. 23. Ranjan R, Gaba S, Goel L, Asif N, Kalra M, Kumar R, Kumar A. In vivo comparison of a fixed loop (EndoButton CL) with an adjustable loop (TightRope RT) device for femoral fixation of the graft in ACL reconstruction: A prospective randomized study and a literature review. Journal of Orthopaedic Surgery. 2018;26(3):2309499018799787
24. Colombet P, Saffarini M, Bouguennec N. Clinical and functional outcomes of anterior cruciate ligament reconstruction at a minimum of 2 years using adjustable suspensory fixation in both the femur and tibia: a prospective study. Orthopedic journal of sports medicine. 2018;6(10):2325967118804128.
25. Choi NH, Park TH, Oh WK, Victoroff BN. Radiologic and clinical outcomes after hamstring anterior cruciate ligament reconstruction using an adjustable-loop cortical suspension device with re-tensioning and knot tying. Arthroscopy: The Journal of Arthroscopic & Related Surgery. 2019;35(9):2629-33.
26. Kouloumentas P, Kavroudakis E, Charalampidis E, Kavroudakis D, Triantafyllopoulos GK. Superior knee flexor strength at 2 years with all-inside short-graft anterior cruciate ligament reconstruction vs a conventional hamstring technique. Knee Surg Sports Traumatol Arthrosc. 2019;27(11):3592–3598.
27. Monaco E, Redler A, Fabbri M, Proietti L, Gaj E, Daggett M, et al. Isokinetic flexion strength recovery after ACL reconstruction: a comparison between all inside graft-link technique and full tibial tunnel technique. Phys Sportsmed. 2019;47(1):132–135.
28. Monaco E, Fabbri M, Redler A, Gaj E, De Carli A, Argento G, et al. Anterior cruciate ligament reconstruction is associated with greater tibial tunnel widening when using a bioabsorbable screw compared to an all-inside technique with suspensory fixation. Knee Surg Sports Traumatol Arthrosc. 2018;27(8):2577–2584.
29. Baldassarri M, Perazzo L, Ghinelli D, Ricciarelli M, Pilla F, Buda R. Return to sport after ACL surgery: a comparison between two different reconstructive techniques. J Knee Surg. 2019;32(6):513–518.
30. Volpi P, Bait C, Cervellin M, Denti M, Prospero E, Morenghi E, et al. No difference at two years between all inside transtibial technique and traditional transtibial technique in anterior cruciate ligament reconstruction. Muscles Ligaments Tendons J. 2014;4(1):95–99.
31. Benea H, d'Astorg H, Klouche S, Bauer T, Tomoaia G, Hardy P. Pain evaluation after all-inside anterior cruciate ligament reconstruction and short-term functional results of a prospective randomized study. Knee. 2014;21(1):102–106.
32. Colombet P, Graveleau N, Jambou S. Incorporation of hamstring grafts within the Tibial tunnel after anterior cruciate ligament reconstruction: magnetic resonance imaging of suspensory fixation versus interference screws. Am J Sports Med. 2016;44(11):2838–2845.
33. Heng CH, Wang BD, Chang PC. Distal femoral fracture after double-bundle anterior cruciate ligament reconstruction surgery. The American Journal of Sports Medicine. 2015;43(4):953-956.

34. de Sa D, Shanmugaraj A, Weidman M, Peterson DC, Simunovic N, Musahl V, et al. All-inside anterior cruciate ligament reconstruction systematic review of techniques, outcomes, and complications. J Knee Surg. 2018;31(9):895–904.
35. Browning WM 3rd, Kluczynski MA, Curatolo C, Marzo JM. Suspensory versus aperture fixation of a quadrupled hamstring tendon autograft in anterior cruciate ligament reconstruction: a meta-analysis. Am J Sports Med. 2017;45(10):2418–2427.
36. Conte EJ, Hyatt AE, Gatt CJ Jr, Dhawan A. Hamstring autograft size can be predicted and is a potential risk factor for anterior cruciate ligament reconstruction failure. Arthroscopy. 2014;30(7):882–890
37. Kern M, Love D, Cotter EJ, Postma W. Quadruple-bundle semitendinosus-Gracilis graft technique for all-inside anterior cruciate ligament reconstruction. Arthrosc Tech. 2016;5(6):e1317–e1320
38. Sheth H, Salunke AA, Barve R, Nirkhe R. Arthroscopic ACL reconstruction using fixed suspensory device versus adjustable suspensory device for femoral side graft fixation: What are the outcomes? J Clin Orthop Trauma. 2019;10(1):138-142.