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ORIGINAL ARTICLE • KNEE - ARTHROSCOPY

Independent clinical appraisal of the Tape Locking Screw (TLS®) anterior cruciate ligament reconstruction technique compared with the hamstring graft technique with a minimum of 12-month follow-up

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Abstract

Introduction The aim of this study was to assess the differential laxity after reconstruction of the anterior cruciate ligament (ACL) by the TLS® technique using a single tendon, the semitendinosus in four-strand graft, compared with the hamstring technique which uses both the gracilis and semitendinosus. We hypothesised that this surgical technique would provide post-surgical differential laxity measurements at least as good as those of the hamstring technique.

Materials and methods We carried out a prospective monocentric study on patients undergoing unilateral anterior cruciate ligament repair between December 2014 and June 2016. All patients were followed up for at least 12 months. The series compares 61 patients operated on using the TLS® technique by the same surgeon, with 33 patients operated on using the hamstring technique by a second surgeon. The main objective of the study was to compare the post-operative differential laxity, measured using the KT1000, between the two techniques.

Results There was no significant difference in the patients' epidemiological characteristics and pre-operative scores between the two groups. Average pre-operative differential laxity was 6.5 mm ± 2.1 (min 3; max 12) in the TLS group and 6.4 mm ± 2.0 (min 0; max 11) in the hamstring group, with no statistically significant difference. The average post-operative difference in laxity was − 0.1 mm ± 1.9 (min − 5; max 4) in the TLS group and 0.3 mm ± 2.0 (min − 7; max 5) in the hamstring group. Again, no significant difference was observed between groups.

Discussion This study demonstrates a level of post-operative differential laxity control using TLS comparable with that of the ACL reconstruction technique using a hamstring graft with preserved tibial insertion.

Level of evidence II, prospective cohort study.

Keywords Anterior cruciate ligament · Laxity · Tape Locking Screw (TLS®) · ST4 · Hamstring graft

Introduction

In 2011, Collette described a surgical technique for ACL reconstruction using a single tendon (the semitendinosus) called "short" or ST4 autograft [1]. It was fixed with two TLS® 7-mm braided polyethylene terephthalate tapes, allowing a 500 N pretension of the four-strand semitendinosus graft, and two specific tibial and femoral TLS® interference screws, inserted using the outside-in method [1]. This pretension means the graft requires less stretching post-operatively than can often be needed with standard grafts [2–7].

The short grafts are made possible since it has been proven that a short insertion into the bone tunnels is possible [8, 9]. In 2011, Lubowitz showed that this technique offered the advantage of blind tunnels, preserving both femoral and tibial bone stocks, and required less tendon damage by sparing the gracilis that in turn reduces the muscle deficit in the flexor muscles occurring when a combined semitendinosus and gracilis graft is taken [10–13]. Nevertheless, this technique is the subject of some controversy [14], notably

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regarding its tibial fixation system, which remains to be optimised.

In theory, the main disadvantage of this technique is that the graft size is chosen arbitrarily (between 45 and 65 mm depending on patient gender and size) with no prior knowledge of the intra-articular length actually required for any given patient. If the length of the blind tunnels is insufficient, this means it is theoretically impossible to adjust the graft tension satisfactorily when fixing it. Apart from the practitioners who developed this technique, few evaluation studies have been performed, and its medium-term results are not yet widely published.

This study's objective was to compare post-operative differential laxity using this technique with the differential laxity using the hamstring technique. Evaluation of laxity was done over at least 12 months post-operatively using the KT1000 arthrometer. Its secondary objectives were to compare the functional results and the short-term complications of the two techniques.

The hypothesis was that the results obtained with this single-tendon surgical technique would be at least equivalent in terms of laxity to those of the traditional hamstring technique.

Materials and methods

Population

An independent, monocentric observational prospective study was carried out between December 2014 and June 2016 with the agreement of the patients or their legal representatives. Inclusion criteria were the presence of a unilateral ACL rupture (confirmed by MRI) with clinical instability despite correct rehabilitation; pre-operative assessment by KT1000 arthrometer (MedMetric, San Diego, CA, USA) identifying a translation of at least 3 mm compared with the contralateral knee [15]; and no history of surgery to either knee. Pre-operative parameters analysed were age, gender, BMI, sporting activity, presence of a bone bruise on the MRI, concomitant meniscus damage and the presence of a pre-operative pivot shift. The ST4 cohort consisted of 69 patients operated on by a surgeon who only performs the ST4 technique. The second cohort consisted of 37 patients operated on by a surgeon who only performs the hamstring technique. The epidemiological characteristics of the two cohorts are summarised in Table 1. Eight patients in the ST4 group were lost to follow-up ($n=61$), and four in the hamstring group ($n=33$).

Surgical technique

The TLS® surgical technique followed the short, four-strand semitendinosus graft technique described by Colette and Cassard in 2011 [1]. Graft length was 50 mm for 15 patients and 55 mm for the other 46 patients. Average graft diameter was 9.5 mm ± 0.9 (min 7; max 11). The graft was tightened within the joint using the artifice of "the sardine box" (Fig. 1). The hamstring surgical technique with preserved tibial insertion was performed as reported by Saragaglia [16]. All grafts in this group had a length of 120 mm. Average graft diameter was 8.6 mm ± 0.7 (min 7; max 10). No

Table 1 Population characteristics: average [interval] and % of total population

	ST4 ($n=61$)	ST-G ($n=33$)	p value
Age (years)	31.7 ± 13.7 [14–70]	32.9 ± 12 [18–53]	0.66
Gender			
Male	49 (80%)	22 (67%)	0.22
Female	12 (20%)	11 (33%)	
BMI (kg/m^2)	24.2 ± 4.4	24.5 ± 3.7	0.76
Average follow-up	19.3 ± 6.3 [12–30]	17.7 ± 6.3 [12–32]	0.24
Knee operated on			
Right	37 (61%)	13 (39%)	0.08
Left	24 (39%)	20 (60%)	
Circumstances of accident			
Sport	45 (74%)	26 (79%)	
Daily life	16 (26%)	7 (21%)	
Clinical pivot shift	36 (59%)	12 (36%)	0.06
Meniscus damage on MRI	26 (43%)	20 (60%)	0.15
Medial meniscus	18 (30%)	9 (27%)	
Lateral meniscus	5 (8%)	6 (18%)	
Both menisci	3 (5%)	5 (15%)	
Bone bruise on MRI	54 (88%)	14 (42%)	< 0.01

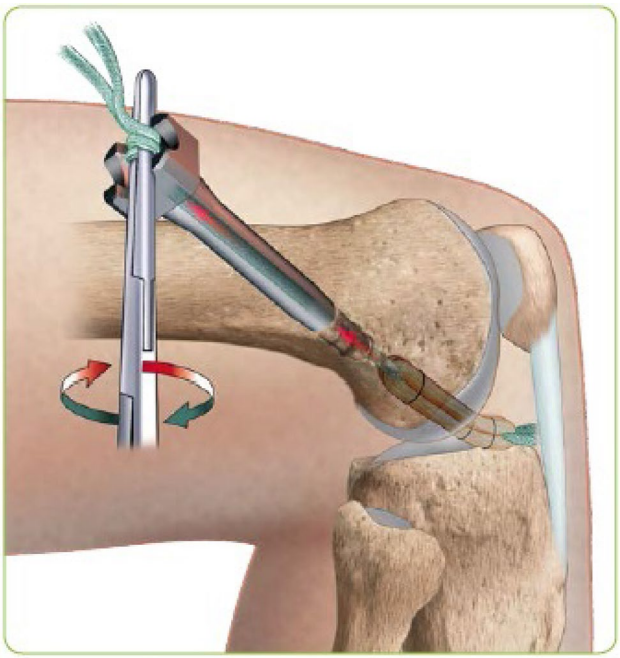

Fig. 1 Artifice of "the sardine box." *Source*: Operative technique TLS® FH Orthopedics (with permission)

lateral tenodesis was performed. The maximum tension of the graft was obtained manually with the knee flexed at 20° after 10 cycling repetitions. Eleven patients in each group also underwent meniscectomy or meniscal suture during the operation. Both groups had the same rehabilitation programme. Physiotherapy commenced the day after surgery with full weight-bearing. The objective was to regain a complete range of knee joint motion, firstly in extension and subsequently in flexion. Proprioception training was initiated after 3 months. Sporting activities without pivot were permitted at 6 months, and unrestricted sporting activities were allowed from ninth month onwards.

Evaluation

The principal criterion was the measurement of sagittal differential laxity. All patients were preoperatively examined under anaesthesia by the lead surgeon. Anterior laxity in 15° flexion was measured using the KT1000 arthrometer following the maximum manual Lachman test. The same evaluation (without anaesthesia) was performed at the 12-month follow-up visit. A differential laxity of 3 mm or less was considered satisfactory [17]. All patients were re-examined by their surgeon during follow-up visits at 4, 6, 12 and 24 months post-surgery. Additional visits could be undertaken as required, for example in case of complications.

The secondary criteria consisted of frequency of post-operative complications (thromboembolism, re-rupture, meniscus damage, cyclops syndrome, complex regional pain syndrome (CRPS)), time off sport and subjective evaluation using the IKDC, Lysholm and Tegner scores. Each patient completed these scores at the final follow-up visit.

Surgical details, peri- and post-operative complications and any revision surgery were noted in the patient files during the follow-up visits and upon review by an independent examiner.

Statistical analysis

Results were analysed using the SPSS® (SPSS Ins, Chicago) statistics software. The Gaussian distribution was verified using the Shapiro–Wilk test. Equality of variance was evaluated using both Fisher's *f* test and Levene's test in order to measure the conditions of homoscedasticity demanded for parametric testing. The significance threshold chosen was $p < 0.05$. Initial analysis was descriptive, expressed in terms of mean, median and standard deviation. A comparative analysis was subsequently performed with matched Student *t* tests and power analysis. The number of subjects necessary was calculated using a Bayesian approach, with an initial alpha risk of 0.05. A minimum of 32 patients was calculated to objectify a post-operative differential laxity of < 3 mm.

Results

Laxity

Mean pre-operative differential laxity was 6.5 mm ± 2.1 (min 3; max 12) in the TLS group and 6.4 mm ± 2.0 (min 0; max 11) in the hamstring group. Mean differential post-operative laxity was − 0.1 ± 1.9 (min − 5; max 4) in the TLS group and 0.3 mm ± 2.0 (min − 7; max 5) in the hamstring group. No significant difference between groups was observed pre- or post-operatively. 92% of patients presented a differential laxity of less than 3 mm (in certain cases less than the contralateral knee) in the TLS group, compared with 97% in the hamstring group.

Complications

In the TLS group, complications were noted in 13% of cases. Three patients (4.9%) were diagnosed with cyclops syndrome and re-operated on at 8, 9 and 12 months after the initial surgery. Two out of 3 had 5 degrees of flexion, and the remaining patient had 10 degrees. The graft diameters in these cases were either 10 mm ($n = 2$) or 9 mm. Two patients had a medial meniscus lesion following the ligamentoplasty and were re-operated at 3 and 12 months, respectively. One patient developed CRPS at 2 months. Two clinical re-ruptures (3.3%) confirmed by MRI were found at 12 and 18 months post-surgery.

Complications were noted in 3 patients (9.1%) in the hamstring group. One re-rupture occurred at 11 months. One patient presented a medial meniscus lesion at 22 months. Finally, one patient was re-operated on at 3 months for a femoral interference screw not enough introduced that extended beyond the external cortical bone resulting in a windshield wiper effect.

Functional evaluation

A comparison of pre- and post-operative functional scores is shown in Table 2. Patients recommenced a sporting activity (in-line movements only) after an average of 6.1 months post-surgery in the TLS group and 7.1 months in the hamstring group ($p = 0.04$).

Discussion

The TLS technique appears to offer good results at 1-year follow-up in terms of differential laxity. This outcome was equivalent to that of the hamstring technique, confirming the original hypothesis.

The first limitation of this study is that the design was neither randomised nor controlled (2 surgeons, each dedicated to 1 technique for 1 group of patients); thus, a possible bias may exist. Secondly, the observers were not independent and were, in addition, the surgeons responsible for each intervention. Patient auto-evaluation was, however, used for the IKDC, Lysholm and Tegner scores. Another possible source of bias is that pre-operative measurement of anteroposterior laxity was obtained under anaesthesia by the surgeon using the KT1000 laximeter, whilst laxity measurement at follow-up was recorded in the clinic by an independent examiner. However, Sernert et al. [18] have shown that this measurement is very reproducible with little intra- or inter-observer variation and is not significantly influenced by anaesthesia. Furthermore, the KT1000 remains the reference examination in clinical practice, used either as a diagnostic aide (differential laxity > 3 mm) or for follow-up [17].

The TLS technique entails using a larger diameter graft (+ 0.9 mm) than the hamstring technique; however, this does not offer any improvement in mean differential laxity, nor an increase in graft diameter linked with a lower incidence of re-rupture, as shown by the 3.2% incidence in the TLS group, compared with the 3.0% in the hamstring group. These results are comparable with the 3.5% described by Lewis et al. [19] over 921 operations using the patellar tendon or the hamstring tendons. However, this study showed a high prevalence of cyclops syndrome (4.9%) in the TLS group, higher than that described by Robert et al. [20] using the same technique. Graft size does not seem to be the cause [21], and the bone tunnels were correctly positioned [22].

The risk of over-tensioning is probably increased with the TLS® technique since the mechanical device employed to determine the right positioning and the tension on the graft is more powerful than the manual tension used in the hamstring technique. Sherman explains that high tension applied in flexion can increase the risk of flexion contractures [23].

The differential laxity observed in this study for the TLS technique (92% < 3 mm) is comparable with the other common short graft techniques described in the literature (Table 3) [1, 20, 24–27]. Robert et al. reported 83% of laxity < 3 mm [20] and Lewis 77% [19]. Other studies evaluating four-strand semitendinosus ACL reconstruction techniques have shown that laxity appears to be less well-controlled when endobutton fixation is used. Bressy et al. [24] reported

Table 2 Functional scores

	ST4 ($n = 61$)	ST-G ($n = 33$)	p value
Pre-surgery			
Lysholm	41.0 ± 12.9	42.6 ± 14.5	0.32
Tegner	6.2 ± 1.5	6.1 ± 1.6	0.71
IKDC	39.7 ± 12.2	40.6 ± 14.4	0.54
Post-surgery			
Lysholm	95.5 ± 9.8	95.9 ± 7.0	0.8
Tegner	4.3 ± 1.4	5.5 ± 1.8	< 0.01
IKDC	94.2 ± 11.2	95.7 ± 7.3	0.43

Table 3 Literature review

	Year	No. of patients	Post-operative differential laxity (Δ) in mm	Fixation system	IKDC	Lysholm
Collette et al. [1]	2011	134	1.5–3.7	TLS	NC	NC
Robert et al. [20]	2011	74	1.9	TLS	92	94
Orfeuvre et al. [25]	2018	61	− 0.1	TLS	94.1	95.5
Lubowitz et al. [26]	2015	43	1.1	Endobutton	83.8	NC
Bressy et al. [24]	2016	35	2.8	Adjustable endobutton	71.8	79.6
Schurz et al. [27]	2016	79	1.7	Adjustable endobutton	89.7	93.1

NC non-communicated

poor control of differential laxity with an endobutton, 46% of patients presenting a residual laxity of > 3 mm. It is possible that the difference observed in our study (92 vs. 46%) is due to the tape fixation system used in the TLS technique. The similarity in differential laxity between TLS, patellar tendon and hamstring tendon techniques has already been reported in the meta-analysis conducted by Poehling-Monaghan et al. in 2017 [28].

Regarding the IKDC, Lysholm and Tegner functional scores, our results are comparable with those previously published. In the TLS group, the Lysholm score rose from 41 to 95.5 points, with no statistically significant difference compared with the hamstring group, which is coherent with the improvement in knee stability following the surgery. In a literature review looking at patellar tendon and hamstring tendon ligamentoplasties, Lewis et al. [19] found a Lysholm score higher than 85 points in seven of eight studies, whilst for Poehling-Monaghan et al. [28] the score was higher than 81 points in 7 studies. The same is true for improvement in mean IKDC score, where an improvement in the functional knee score is reported following surgery [19, 28]. This is concordant with our results (increase from 39.7 to 94.1 points) in the TLS group. This score correlates with a healthy knee in a population of 25–34-year-old Americans (score of 94 points) [29]. For return to sporting activity, there was a reduced level of activity at 1 year in both groups. Notarnicola et al. [30] with a 13-month follow-up reported similar results in 80 amateur athletes who had a pre-operative Tegner score of 6.9 points and a post-operative score of 3.9 points. In a study by Hetsroni et al. [31] where young fit patients were followed for 5–10 years, a high level of sporting activity prior to surgery and an early stabilisation of the knee allowed a better return to the previous level of activity. The reduction in activity level we observed could be explained by the medium-term follow-up, meaning that patients had not yet reached their level of activity prior to injury. The Tegner score at 1 year in the hamstring group is significantly better than that in the TLS group. Patients reached their previous level of sporting activity more quickly in the hamstring group than in the TLS group.

Conclusion

This study demonstrates that the TLS® technique offers a post-operative differential laxity control comparable with the ACL reconstruction technique using the hamstring tendons with preserved tibial insertion. The re-rupture rate is also equivalent. A higher incidence of surgical revision for cyclops syndrome was found in the TLS group. Strong tension is recommended for the classical hamstrings graft technique, whereas a lower tension is sufficient for the TLS technique as the graft and fixations are stiffer.

Compliance with ethical standards

Conflict of interest On behalf of all authors, the corresponding author states that there is no conflict of interest.

Ethical approval This article does not contain any studies with human participants or animals performed by any of the authors.

Informed consent Informed consent was obtained from all individual participants included in the study.

References

1. Collette M, Cassard X (2011) The Tape Locking Screw technique (TLS): a new ACL reconstruction method using a short hamstring graft. Orthop Traumatol Surg Res 97:555–559. https://doi.org/10.1016/j.otsr.2011.03.016
2. Kousa P, Järvinen TLN, Vihavainen M, Kannus P, Järvinen M (2003) The fixation strength of six hamstring tendon graft fixation devices in anterior cruciate ligament reconstruction. Part II: tibial site. Am J Sports Med 31:182–188. https://doi.org/10.1177/03635465030310020501
3. Adam F, Pape D, Schiel K, Steimer O, Kohn D, Rupp S (2004) Biomechanical properties of patellar and hamstring graft tibial fixation techniques in anterior cruciate ligament reconstruction: experimental study with roentgen stereometric analysis. Am J Sports Med 32:71–78. https://doi.org/10.1177/0095399703258608
4. Brown CH, Wilson DR, Hecker AT, Ferragamo M (2004) Graft-bone motion and tensile properties of hamstring and patellar tendon anterior cruciate ligament femoral graft fixation under cyclic loading. Arthroscopy 20:922–935. https://doi.org/10.1016/j.arthro.2004.06.032
5. Höher J, Livesay GA, Ma CB, Withrow JD, Fu FH, Woo SL (1999) Hamstring graft motion in the femoral bone tunnel when using titanium button/polyester tape fixation. Knee Surg Sports Traumatol Arthrosc 7:215–219. https://doi.org/10.1007/s001670050151
6. To JT, Howell SM, Hull ML (1999) Contributions of femoral fixation methods to the stiffness of anterior cruciate ligament replacements at implantation. Arthroscopy 15:379–387
7. Cavaignac E, Coulin B, Tscholl P, Fatmy NNM, Duthon V, Menetrey J (2017) Is quadriceps tendon autograft a better choice than hamstring autograft for anterior cruciate ligament reconstruction? A comparative study with a mean follow-up of 3.6 years. Am J Sports Med 45:1326–1332. https://doi.org/10.1177/0363546516688665
8. Rodeo SA, Kawamura S, Kim H-J, Dynybil C, Ying L (2006) Tendon healing in a bone tunnel differs at the tunnel entrance versus the tunnel exit: an effect of graft-tunnel motion? Am J Sports Med 34:1790–1800. https://doi.org/10.1177/0363546506290059
9. Bedi A, Kawamura S, Ying L, Rodeo SA (2009) Differences in tendon graft healing between the intra-articular and extra-articular ends of a bone tunnel. HSS J 5:51–57. https://doi.org/10.1007/s11420-008-9096-1
10. Tashiro T, Kurosawa H, Kawakami A, Hikita A, Fukui N (2003) Influence of medial hamstring tendon harvest on knee flexor strength after anterior cruciate ligament reconstruction. A detailed evaluation with comparison of single and double tendon harvest. Am J Sports Med 31:522–529. https://doi.org/10.1177/03635465030310040801

11. Condouret J, Cohn J, Ferret J-M, Lemonsu A, Vasconcelos W, Dejour D, Potel J-F, Société française d'arthroscopie (2008) Isokinetic assessment with two years follow-up of anterior cruciate ligament reconstruction with patellar tendon or hamstring tendons. Rev Chir Orthop Reparatrice Appar Mot 94:375–382. https://doi.org/10.1016/j.rco.2008.09.006
12. Ardern CL, Webster KE (2009) Knee flexor strength recovery following hamstring tendon harvest for anterior cruciate ligament reconstruction: a systematic review. Orthop Rev 1:e12. https://doi.org/10.4081/or.2009.e12
13. Nakamura N, Horibe S, Sasaki S, Kitaguchi T, Tagami M, Mitsuoka T, Toritsuka Y, Hamada M, Shino K (2002) Evaluation of active knee flexion and hamstring strength after anterior cruciate ligament reconstruction using hamstring tendons. Arthroscopy 18:598–602
14. Connaughton AJ, Geeslin AG, Uggen CW (2017) All-inside ACL reconstruction: how does it compare to standard ACL reconstruction techniques? J Orthop 14:241–246. https://doi.org/10.1016/j.jor.2017.03.002
15. Boyer P, Djian P, Christel P, Paoletti X, Degeorges R (2004) Reliability of the KT-1000 arthrometer (Medmetric) for measuring anterior knee laxity: comparison with Telos in 147 knees. Rev Chir Orthop Reparatrice Appar Mot 90:757–764
16. Saragaglia D (2014) Ligamentoplastie du ligament croisé antérieur de type mono-faisceau. In: D. Huten Conférences d'enseignement 2014 SOFCOT under direction of Hulet C, Potel JF. Elservier, Masson, p 155
17. Kilinc BE, Kara A, Celik H, Oc Y, Camur S (2016) Evaluation of the accuracy of Lachman and Anterior Drawer Tests with KT1000 ın the follow-up of anterior cruciate ligament surgery. J Exerc Rehabil 12:363–367. https://doi.org/10.12965//jer.1632622.311
18. Sernert N, Kartus J, Köhler K, Ejerhed L, Karlsson J (2001) Evaluation of the reproducibility of the KT-1000 arthrometer. Scand J Med Sci Sports 11:120–125
19. Lewis PB, Parameswaran AD, Rue J-PH, Bach BR (2008) Systematic review of single-bundle anterior cruciate ligament reconstruction outcomes: a baseline assessment for consideration of double-bundle techniques. Am J Sports Med 36:2028–2036. https://doi.org/10.1177/0363546508322892
20. Robert H, Limozin R, de Polignac T (2011) Single-bundle reconstruction in quadruple Semi tendinosus graft of the ACL according to the TLS technique. Clinical results of a series of 74 knees with minimum 18 months follow-up. Rev Chir Orthop Trauma 97:40–45
21. Fujii M, Furumatsu T, Miyazawa S, Okada Y, Tanaka T, Ozaki T, Abe N (2015) Intercondylar notch size influences cyclops formation after anterior cruciate ligament reconstruction. Knee Surg Sports Traumatol Arthrosc 23:1092–1099. https://doi.org/10.1007/s00167-014-2891-y
22. Aglietti P, Buzzi R, Giron F, Simeone AJ, Zaccherotti G (1997) Arthroscopic-assisted anterior cruciate ligament reconstruction with the central third patellar tendon. A 5-8-year follow-up. Knee Surg Sports Traumatol Arthrosc 5:138–144. https://doi.org/10.1007/s001670050041
23. Sherman SL, Chalmers PN, Yanke AB, Bush-Joseph CA, Verma NN, Cole BJ, Bach BR (2012) Graft tensioning during knee ligament reconstruction: principles and practice. J Am Acad Orthop Surg 20:633–645. https://doi.org/10.5435/JAAOS-20-10-633
24. Bressy G, Brun V, Ferrier A, Dujardin D, Oubaya N, Morel N, Fontanin N, Ohl X (2016) Lack of stability at more than 12 months of follow-up after anterior cruciate ligament reconstruction using all-inside quadruple-stranded semitendinosus graft with adjustable cortical button fixation in both femoral and tibial sides. Orthop Traumatol Surg Res 102:867–872. https://doi.org/10.1016/j.otsr.2016.08.011
25. Orfeuvre B, Pailhé R, Sigwalt L, Duval BR, Lateur G, Plaweski S, Saragaglia D (2018) Anterior cruciate ligament reconstruction with the Tape Locking Screw (TLS) and a short hamstring graft: Clinical evaluation of 61 cases with a minimum 12 months' follow-up. Orthop Traumatol Surg Res OTSR. https://doi.org/10.1016/j.otsr.2018.03.016
26. Lubowitz JH (2012) All-inside anterior cruciate ligament graft link: graft preparation technique. Arthrosc Tech 1:e165–168. https://doi.org/10.1016/j.eats.2012.06.002
27. Schurz M, Tiefenboeck TM, Winnisch M, Syre S, Plachel F, Steiner G, Hajdu S, Hofbauer M (2016) Clinical and Functional Outcome of All-Inside Anterior Cruciate Ligament Reconstruction at a Minimum of 2 Years' Follow-up. Arthrosc J Arthrosc Relat Surg Off Publ Arthrosc Assoc N Am Int Arthrosc Assoc 32:332–337. https://doi.org/10.1016/j.arthro.2015.08.014
28. Poehling-Monaghan KL, Salem H, Ross KE, Secrist E, Ciccotti MC, Tjoumakaris F, Ciccotti MG, Freedman KB (2017) Long-term outcomes in anterior cruciate ligament reconstruction: a systematic review of patellar tendon versus hamstring autografts. Orthop J Sports Med 5:23. https://doi.org/10.1177/2325967117709735
29. Anderson AF, Irrgang JJ, Kocher MS, Mann BJ, Harrast JJ, International Knee Documentation Committee (2006) The International Knee Documentation Committee Subjective Knee Evaluation Form: normative data. Am J Sports Med 34:128–135. https://doi.org/10.1177/0363546505280214
30. Notarnicola A, Maccagnano G, Barletta F, Ascatigno L, Astuto L, Panella A, Tafuri S, Moretti B (2016) Returning to sport after anterior cruciate ligament reconstruction in amateur sports men: a retrospective study. Muscles Ligaments Tendons J 6:486–491. https://doi.org/10.11138/mltj/2016.6.4.486
31. Hetsroni I, van-Stee M, Marom N, Koch JEJ, Dolev E, Maoz G, Nyska M, Mann G (2017) Factors Associated With Improved Function and Maintenance of Sports Activities at 5 to 10 Years After Autologous Hamstring ACL Reconstruction in Young Men. Orthop J Sports Med 5:2325967117700841. https://doi.org/10.1177/2325967117700841

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