Clinical Outcomes After Combined Anterior Cruciate Ligament and Anterolateral Ligament Reconstruction

Jean-Romain Delaloye, MD, Jozef Murar, MD, Mauricio Gonzalez, MD, Thiago Amaral, MD, Vikram Kakatkar, MS Ortho, and Bertrand Sonnery-Cottet, MD

Background: Graft rupture rate, return to sport and persistent rotational instability remain a concern postoperatively following anterior cruciate ligament (ACL) reconstruction. The anterolateral ligament (ALL) has recently been shown to act as a lateral knee stabilizer that helps improve rotational stability. To improve functional and clinical outcomes, a combined ACL reconstruction with an associated ALL reconstruction has been proposed.

Purpose: The main purpose of this study was to evaluate the clinical outcomes of the combined ACL and ALL reconstruction.

Methods: A literature search in PubMed was performed and papers reporting on clinical outcomes after combined ACL and ALL reconstruction were identified. The inclusion criteria was a minimum 2-year follow-up.

Results: Five studies were included in the review. The overall graft failure rate in patients with ACL and ALL reconstruction was <3% at 2 years minimum after surgery. Comparison analysis in a high-risk population demonstrated that the graft failure rate in combined ACL and ALL reconstruction was 2.5 times lower than with isolated bone-patella tendon-bone graft and 3.1 times lower than with isolated hamstring graft. The medial meniscal repair failure rate was also 2 times lower in the combined ACL and ALL reconstruction group compared with isolated ACL reconstruction. Return to sport and functional outcomes did not show any significant difference between the groups. The rate of reoperations was not increased in patients with combined ACL and ALL reconstruction.

Conclusions: Overall, combined ACL and ALL reconstruction provides promising results that may improve graft rupture rates and meniscal repair failure rates, while maintaining excellent functional outcomes.

Key Words: ACL reconstruction—anterolateral ligament—clinical outcome.

(*Tech Orthop* 2018;33: 225–231)

Anterior cruciate ligament (ACL) injury is one of the most common orthopaedic injuries.[1] ACL reconstruction is associated with superior quality of life, sports function, and knee symptoms when compared with nonoperative treatment.[2] Although results of contemporary ACL reconstruction are satisfactory and reliable over time, the graft failure rate is still high (17.1% to 18%),[3–5] the rate of return to preinjury level of sport is low (44% to 72%),[6,7] and postoperative rotational instability is a persistent complaint in up to 25% to 30% of patients.[8,9] This lack of rotational control decreases the return to sport rate and is thought to contribute to secondary meniscal and cartilaginous problems.[10,11]

To resolve this problem and improve knee stability, non-anatomic lateral extra-articular tenodesis (LET) procedures (eg, Lemaire and MacIntosh[12] procedures)[13] have been proposed in the past. Despite good clinical outcomes reported by some authors in the literature,[14–16]these techniques have been progressively abandoned due to reports of poor results, over-constraint, and early degenerative changes of the knee.[17,18] In addition, no prospective controlled studies have demonstrated any clinical advantage of these procedures.[19,20]

The existence and function of the anterolateral ligament (ALL) has been heavily debated and challenged by many authors in the literature. However, its recent "rediscovery,"[21,22] could be the anatomic missing link to improve rotatory instability in ACL deficient knees. Recent anatomic and biomechanical studies demonstrated that the ALL restrains internal rotation of the tibia throughout varying degrees of knee flexion.[21,23–26] These new findings have allowed surgeons to propose and develop new anatomic ALL reconstructions whose clinical results are presented in this article.

ARTICLE IDENTIFICATION AND SELECTION

Since 2013, orthopaedic surgeons have demonstrated a renewed interest in the anterolateral structures of the knee, with >450 articles being published on the ALL. Two investigators independently identified articles available in Pubmed about ALL reconstruction and clinical outcomes using the following terms: Anterolateral ligament, ALL, and reconstruction. We then selected all articles reporting on clinical outcomes with a minimum follow-up of 2 years. To our knowledge, only 8 studies reported clinical outcomes after ALL reconstruction.[27–34] Among them, 3 were excluded due to a follow-up shorter than 2 years.[30,32,34] This review will focus on the remaining 5 clinical studies, whose characteristics are summarized in Table 1. Of note, 4 studies are from the same group (SANTI group), however, there is no overlap or "doubling up" of patients in the data analysis.

SURGICAL TECHNIQUE

Of the 5 studies, the 4 published by the SANTI group had the same surgical technique. This technique for combined ACL and ALL reconstruction utilized the hamstring tendons as grafts for the ACL and ALL and has previously been described.[35]

The Gracilis tendon was detached from its tibial insertion and sutured to a tripled semitendinosus graft left attached on its tibial insertion. The femoral insertion of the ALL (slightly

From the Centre Orthopédique Santy, FIFA Medical Centre of Excellence, Groupe Ramsay-Générale de Santé, Hôpital Privé Jean Mermoz, Lyon, France.

B.S.-C. receives royalties from, and is a paid consultant for Arthrex Inc. The remaining authors declare that they have nothing to disclose.

For reprint requests, or additional information and guidance on the techniques described in the article, please contact Bertrand Sonnery-Cottet, MD, at sonnerycottet@aol.com or by mail at Centre OrthopédiqueSanty, 24 Avenue Paul Santy, Lyon 69008, France. You may inquire whether the author(s) will agree to phone conferences and/or visits regarding these techniques.

TABLE 1. Characteristics of Included Studies

References	Type of Study	LOE	No. Patients	Age of Patients [Mean ± SD or (Range)] (y)	Male Sex [n (%)]	Follow-up [Mean ± SD or (Range)] (mo)
Sonnery-Cottet et al[28]	Case series	IV	92	24 ± 9	68 (73.9)	32 ± 4
Thaunat et al[29]	Case series	IV	548	24 ± 8	385 (70.3)	36 ± 8
Sonnery-Cottet et al[27]	Cohort study	II	502 (281 ACLR, 221 ACLR+ALLR)	22 ± 4	364 (72.5)	38 ± 9
Ibrahim et al[31]	RCT	II	110 (54 ACLR, 56 ACLR+ALLR)	26 (20-32)	110 (100)	27 (25-30)
Sonnery-Cottet et al[33]	Cohort study	III	383 (194 ACLR, 189 ACLR+ALLR)	27 ± 9	293 (76.5)	37 ± 9

ACLR indicates anteriorcruciate ligament reconstruction; ALLR, anterolateral ligament reconstruction; LOE, level of evidence; NA, non available; RCT, randomized controlled trial.

proximal and posterior to the lateral epicondyle) was identified and was used as a starting point for the ACL femoral tunnel using an outside-in guide. For the tibial ALL insertion, 2 stab incisions were made 1 cm distal to the joint line; one just posterior to Gerdy's tubercle and the other just anterior to the fibula head. A 4.5-mm drill was used to create 2 convergent bone tunnels through these stab incisions. The ACL and ALL grafts were then routed through the knee. Fixation of the ACL graft was performed with the knee in 20 degrees of flexion. The Gracilis ALL graft emerging from the femoral tunnel was shuttled deep to the iliotibial band, through the convergent tibial tunnels, and then was brought back toward the femur through the proximal incision. ALL graft fixation was performed in full extension and neutral rotation (Fig. 1).

Postoperatively, patients participated in a standardized rehabilitation program consisting of brace-free, immediate full weight-bearing, and progressive range of motion exercises.[27] Early rehabilitation was focused on obtaining full extension and quadriceps activation. A gradual return to sports was allowed starting at 4 months for nonpivoting sports, 6 months for pivoting noncontact sports, and 8 to 9 months for pivoting contact sports. The return to pivoting noncontact sport was delayed if isokinetic testing at 6 months showed a deficit $>20\%$ in eccentric or concentric hamstring strength or any quadriceps deficit. In this situation, repeat testing was performed after 2 more months of rehabilitation.

In the study by Ibrahim and colleagues, the surgical technique for ALL reconstruction used a gracillis tendon graft that was percutaneously affixed by interference screw proximal and anterior to the lateral collateral ligament. The graft was then shuttled deep to the iliotibial band and inserted at the anatomically described ALL tibial insertion site halfway between Gerdy's tubercle and the fibular head, ~1 cm below the joint line. This was secured into place using an interference screw at 30 degrees of knee flexion and neutral rotation.

CLINICAL RESULTS

In 2015, Sonnery-Cottet et al[28] published the first clinical series of 92 patients who underwent a combined ACL and ALL reconstruction. At a mean follow-up of 32.4 months (range, 24 to 39 mo), all patients demonstrated a full range of motion of

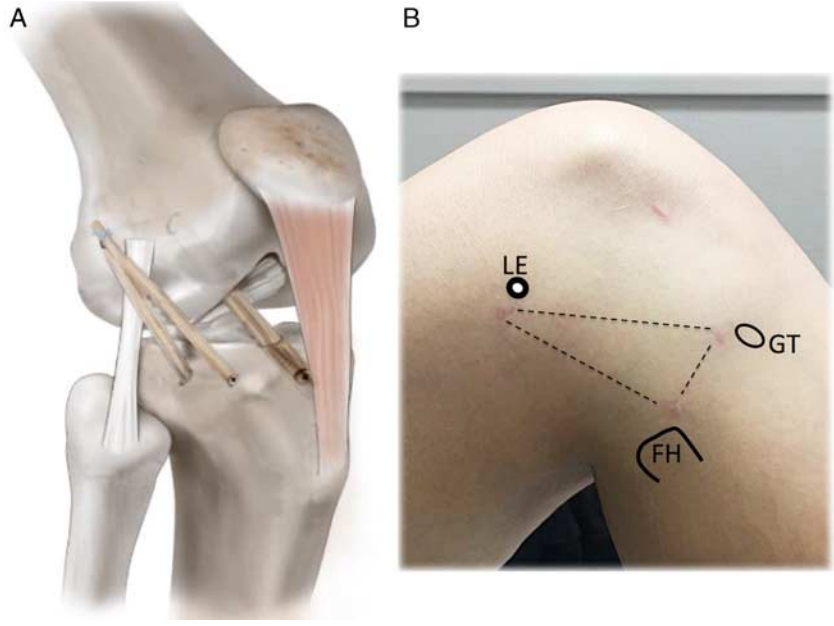

FIGURE 1. A, Combined ACL and ALL reconstruction. B, Stab incisions 3 months after surgery. Dotted line represents ALL graft. ACL indicates anterior cruciate ligament; ALL, anterolateral ligament; FH, fibula head; GT, Gerdy's tubercle; LE, lateral epicondyle. full color online

the knee and a side to side laxity of 0.7 ± 0.8 mm. Objective International Knee Documentation Committee (IKDC) scores increased significantly after the surgery ($P < 0.0001$) with 91.6% of patients graded A and 8.4% graded B due to a grade 1 pivot shift test. IKDC subjective score, Lysholm and Tegner scores also increased significantly after the surgery; at the last follow-up, they were 86.7 ± 12.3, 92 ± 9.8, and 7.1 ± 1.8, respectively.

A second study, in which 221 patients underwent a combined ACL and ALL reconstruction confirmed these results. The subjective scores were obtained at a mean follow-up of 35.4 ± 8.4 months and included an IKDC score of 81.8 ± 13.1, Lysholm score of 91.9 ± 10.2, and a Tegner score of 7.0 ± 2.0.[27] Subjective and objective results after combined ACL and ALL reconstruction did not show any significant difference when compared with isolated ACL reconstruction using bone-patellar tendon-bone (B-PT-B) or quadrupled hamstring tendon (4HT) grafts in a population of 502 young patients participating in high-risk pivoting sports.[27]

In another comparative study of 110 patients, Ibrahim and colleagues also found that clinical outcomes were not significantly different after isolated ACL reconstruction compared with combined ACL and ALL reconstruction except for the KT-1000 arthrometer values. The combined ACL and ALL reconstruction median was 1.3 mm, while the isolated ACL reconstruction median was 1.8 mm ($P < 0.001$).

GRAFT RUPTURE

Graft rupture is a major concern after ACL reconstruction occurring in up to 18% of high-risk patients.[4] Combined procedures are proposed to reduce forces transmitted to the ACL graft and protect it during ligamentisation, with the expectation that this will result in a reduced graft rupture rate.[36,37] Graft failure rates of <3% were seen in the 2 case series from the SANTI group with a minimum follow-up of 2 years.[28,29]

Although Ibrahim et al[31] did not report any graft rupture in his study Sonnery-Cottet et al[27] demonstrated that combined ACL and ALL reconstruction in a high-risk population was associated with significantly decreased graft rupture rates when compared with isolated ACL reconstructions. These graft rupture rates were found to be 10.77% (range, 6.60% to 17.32%) for 4HT grafts, 16.77% (9.99% to 27.40%) for B-PT-B grafts and 4.13% (2.17% to 7.80%) for hamstring tendon graft combined with ALL (HT +ALL) at a mean follow-up of 38.4 months (Fig. 2).

When the differences in the demographics of the population were accounted for in multivariate analysis applying the Bonferroni-Holm correction, the rate of graft failure in HT+ALL was 3.1 times lower than the 4HT group and 2.5 times lower than the B-PT-B group. Meanwhile, there was no statistically significant difference in the graft failure rate between 4HT and B-PT-B groups. These clinical studies confirm that ALL reconstruction does provide a protective role on the ACL graft and would result from an increased rotational stability and load sharing.[27,36]

REOPERATION RATES

The rates of reoperation after ACL reconstruction remain higher than desired and vary widely within the peer-reviewed literature from 18.9% to 26.7%.[38,39] After combined ACL and ALL reconstruction, early studies demonstrated that this procedure did not appear to be associated with increased risk of reoperation at a minimum 2-year follow-up. Indeed, the first clinical series reported that 8 of 92 patients required a reoperation of the ipsilateral knee (8.7%) while 7 patients sustained a

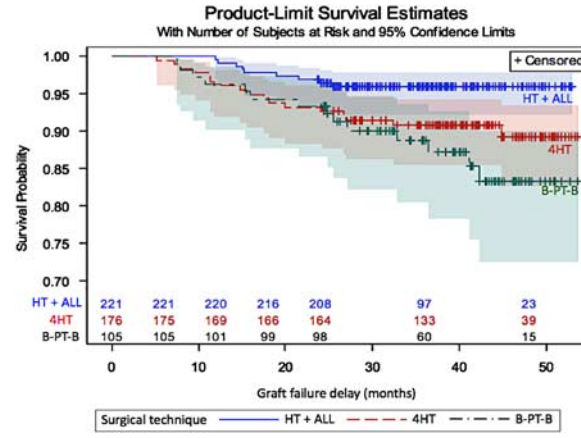

FIGURE 2. Survivorship data from Kaplan-Meier analysis stratified by anterior cruciate ligament reconstruction technique. ALL indicates anterolateral ligament; B-PT-B, bone-patellar tendon-bone; HT, hamstring tendon. full color online

contralateral ACL rupture (7.6%).[28] Thaunat et al[29] confirmed these excellent results in a larger and more recent study including 548 patients. In total, 77 (14.1%) required an ipsilateral knee reoperation, while 47 suffered a contralateral ACL tear (8.6%) at a mean of 20.4 ± 8.0 months after the index procedure. Table 2 summarizes the indications for ipsilateral knee reoperations.

It is also important to note that high rates of knee stiffness and reoperations reported in historical series of nonanatomic, LET, were not observed in the current series.[13,18,40] The only complications specifically related to the ALL procedure (n = 3) were all related to femoral hardware that required removal. In both univariate and multivariate analyses, only the presence of a medial meniscal lesion at the index procedure was significantly associated with ipsilateral reoperation.[27] In the randomized controlled trial recently published by Ibrahim and colleagues, no patient needed a reoperation. The only postoperative complication reported was a superficial infection treated with antibiotics.[31]

MEDIAL MENISCUS TEARS

In a comparative study including 383 patients (196 isolated ACL reconstruction and 184 ACL and ALL reconstruction),

TABLE 2. Ipsilateral Knee Reoperations in Patients After ACL and ALL Reconstruction With a Minimum Follow-up of 2 Years

	N (%)	
Reference	**Sonnery-Cottet et al[28]**	**Thaunat et al[29]**
No. patients	92	548
Overall	8 (8.7)	77 (14.1)
Graft rupture	1 (1.1)	14 (2.6)
Arthrofibrosis	0	6 (1.1)
Cyclops	1 (1.1)	16 (2.9)
Meniscus procedures	6 (6.5)	30 (5.5)
Hardware removal	0	4 (0.7)
Arthroscopic lavage without infection	0	4 (0.7)
Deep infection	0	3 (0.5)

ACL indicates anterior cruciate ligament; ALL, anterolateral ligament.

43 patients underwent reoperation for failure of the medial meniscus repair or a new meniscal tear.[33] The survival rate of a meniscal repair at 36 months in the combined ACL and ALL reconstruction group was 91.2% [95% confidence interval (CI), 85.4-94.8] compared with 83.8% (95% CI, 77.1%-88.7%) ($P = 0.033$) in the isolated ACL reconstruction group. The probability of failure of a medial meniscal repair was > 2 times lower in patients with combined ACL and ALL reconstruction compared with patients with isolated ACL reconstruction (hazard ratio, 0.443; 95% CI, 0.218-0.866). No other prognostic factors (eg, age, type of sport, body mass index) significantly influenced medial meniscus repair failure.

Although isolated ACL reconstruction reliably restores anteroposterior stability, excessive tibial rotation may persist, leading to repetitive microinstability events that may contribute to failure of the meniscal repair.[41] It is therefore postulated that the higher failure rate of a medial meniscal repair observed in the isolated ACL reconstruction group is due to failure to fully restore normal knee kinematics.

RETURN TO SPORT

Low rates of return to sport are a major concern after ACL reconstruction, particularly in a high-risk population. One systematic review has demonstrated that on average, only 65% of patients return to their preinjury level of sport and only 55% to competitive sport.[42]

The SANTI group reported that the rate of patients returning to sport at the same level after combined ACL and ALL reconstruction varied between 68.8% and 71.1%.[27,28] Although this rate was higher than for patients who underwent isolated ACL reconstruction using B-PT-B or 4HT grafts, the difference did not reach statistical significance ($P = 0.231$). In addition, in a young and active population, multivariate analysis showed that HT+ALL was associated with a higher odds of returning to preinjury level of sport than the 4HT graft [odds ratio (OR), 1.938; 95% CI, 1.174-3.224], but not compared with B-PT-B graft (OR, 1.460; 95% CI, 0.813-2.613).[27] Irrespective of the type of graft, factors that significantly increased the return to preinjury level of sport were male sex and absence of meniscal tear.

WHY IS ALL RECONSTRUCTION IMPORTANT?

Clinical results after isolated ACL reconstruction in a high-risk population are disappointing. In this population, recent studies reported graft rupture rates vary between 18% and 28%,[3,4,38] and the rate of patients who return to their preinjury level of sport remains low (50% to 65%).[6,43]

ACL-injured knees have a concomitant ALL injury between 51% and 90% of the time.[44,45] Currently, the healing potential of the ALL is not known, but biomechanical studies have shown that isolated ACL reconstruction in combined ALL and ACL-injured knees failed to restore normal kinematics.[46] In this situation, normal knee kinematics could only be restored by ACL reconstruction combined with a LET or with ALL reconstruction fixed in extension.[46]

LET is not a new concept and nonanatomic procedures such as the Lemaire technique have been widely performed in France in the 1970s and 1980s.[13] This technique has been progressively abandoned after the consensus conference of the American Orthopaedic Society for Sports Medicine (AOSSM) in 1989, which focused on the role of LET in the surgical treatment of the ACL deficient knee.[47] The select panel of experts concluded that extra-articular reconstructions were unable to provide any substantial advantage over intra-articular reconstructions and that they eventually resulted in increased morbidity, a higher risk of complications and late osteoarthritis (OA).[48] However, their conclusions were based on surgical techniques and rehabilitation protocols that are no longer used in modern ACL reconstruction. On the basis of our increasing knowledge of ALL anatomy and function, the nonanatomic LET procedure was replaced by an anatomic percutaneous ALL reconstruction. This technique has demonstrated promising clinical results in case series involving > 500 patients who underwent combined ACL and ALL reconstruction.[29]

DISCUSSION

Clinical outcomes after combined ACL and ALL reconstruction are promising despite the ongoing debate about the biomechanical characteristics of the ALL and even its existence.[23,46,49] The SANTI group has shown that ALL reconstruction has a protective effect on the ACL graft as well as on medial meniscal repairs. This is likely attributed to biomechanical load-sharing properties of the ALL graft and improved rotational control of the knee. In their cohort of patients, they reported a graft rupture rate of 3% that is comparable with the 2% rate reported by Marcacci et al[16] at 5 years follow-up using combined intra-articular and extra-articular reconstruction.[50] They also found that ACL graft rerupture rate in high-risk population with combined ACL and ALL reconstruction was significantly lower than in those with isolated ACL reconstruction.[27] This finding was recently supported by Ferretti et al who reported significantly reduced graft failure in patients with an ACL reconstruction combined with a modified MacIntosh procedure compared with those with isolated ACL reconstruction.[51]

The addition of an ALL reconstruction demonstrated a 2 times lower medial meniscal repair failure rate compared with isolated ACL reconstruction.[27,33] The protective effect on the medial meniscal repair could play an important role in long-term preservation of the knee articulation in patients after ACL reconstruction. Claes et al[52] have shown that at a minimum 10-year follow-up post-ACL reconstruction, 50% of patients who underwent a meniscectomy had OA compared with 16% of patients without ameniscectomy (OR, 3.54, 95% CI 2.56-4.91). This finding was recently confirmed by Shelbourne et al[53] who reported a 3 times higher risk of developing OA in patients who underwent a medial meniscectomy at the time of ACL reconstruction at a mean 22.5 years after surgery(OR, 2.98, 95% CI, 1.91-4.66).

As regards the biomechanics of the knee, Schon et al[54] showed in a cadaveric study that an ALL reconstruction overconstrained the internal rotation of the knee. However, these findings have not been confirmed by other biomechanical studies.[55,56] In fact, a clinical study by Ferretti et al[51] showed no increased risk of OA at a minimum of 10 years follow-up in patients who underwent a combined intra-articular and extra-articular reconstruction. Combined ACL and ALL reconstruction has proven to be a safe procedure with an overall reoperation rate that is comparable with those reported for isolated ACL reconstructions.[38,57] The addition of a percutaneous ALL reconstruction demonstrated a very low complication rate (0.5%) related to the ALL graft. Similarly, complications such as donor site morbidity, cosmesisissues, stiffness, loss of motion, patellofemoral crepitation, and degenerative changes in the lateral compartment that have been historically reported in studies after additional extra-articular tenodesis were not encountered.[13,18,40]

TABLE 3. Decision Criteria

Primary Criteria	Secondary Criteria
ACL revision	Contralateral ACL rupture
Pivot shift grade 2 or 3	Δside to side laxity > 7 mm
Segond fracture	Deep lateral femoral notch sign
Hyperlaxity	< 25-y old
Pivoting sport (high level athletes) medial meniscus repair	
1 decisive criteria or 2 secondary criteria = ACL+ALL reconstruction	

ACL indicates anterior cruciate ligament; ALL, anterolateral ligament.

Current indications to perform a combined ACL and ALL reconstruction are still highly debated in the literature, but according to the recent clinical results reported in this review, it appears that isolated ACL reconstruction might be insufficient in young patients involved in pivoting sports, those with high-grade pivot shifts after injury, and in cases of ACL revision.[58] On the basis of excellent clinical outcomes and increasing follow-up of hundreds of patients, Sonnery-Cottet et al recently proposed criteria to identify patients eligible for a combined ACL and ALL reconstruction (Table 3).[59]

Nevertheless, further prospective studies are warranted to clearly determine the most appropriate candidates for this surgical procedure.

The authors acknowledge some limitations to the present review. Except for one randomized controlled trial, all included studies are retrospective and have a nonrandomized design. In these studies the risk of selection bias could not be excluded, although multivariate analyses were performed to mitigate demographic differences between patients. Another limitation is the lack of long-term follow-up studies that could minimize reoperation rates, which is known to increase with time elapsed from the surgery. Therefore, randomized controlled clinical trials and studies with longer follow-up times are needed to confirm the compelling clinical evidence for the efficacy of combined ACL and ALL reconstruction. Lastly, in Ibrahim and colleagues study, the femoral insertion of the ALL graft is nonanatomic as agreed to by the recent anatomic studies, which renders the analysis of the outcomes difficult.[21,60] Future studies should be performed with anatomic ALL reconstructions as suggested by the experts involved in reconstructions and dissections in order to avoid confusion in the literature and to have valid comparative results.[58,59]

CONCLUSIONS

Initial clinical studies showed that a combined ACL and ALL reconstruction is a safe and effective surgical procedure that provides significant reduction of graft rupture rate compared with isolated ACL reconstruction. In addition, it is associated with a significant protective effect on medial meniscus repairs. Further research with randomized controlled trials is needed to confirm these promising results.

REFERENCES

1. Spindler KP, Wright RW. Clinical practice. Anterior cruciate ligament tear. *N Engl J Med*. 2008;359:2135–2142.
2. Ardern CL, Sonesson S, Forssblad M, et al. Comparison of patient-reported outcomes among those who chose ACL reconstruction or non-surgical treatment. *Scand J Med Sci Sports*. 2017;27:535–544.
3. Kamath GV, Murphy T, Creighton RA, et al. Anterior cruciate ligament injury, return to play, and reinjury in the elite collegiate athlete: analysis of an NCAA division i cohort. *Am J Sports Med*. 2014;42:1638–1643.
4. Webster KE, Feller JA. Exploring the high reinjury rate in younger patients undergoing anterior cruciate ligament reconstruction. *Am J Sports Med*. 2016;44:2827–2832.
5. Morgan MD, Salmon LJ, Waller A, et al. Fifteen-year survival of endoscopic anterior cruciate ligament reconstruction in patients aged 18 years and younger. *Am J Sports Med*. 2016;44:384–392.
6. Brophy RH, Schmitz L, Wright RW, et al. Return to play and future ACL injury risk after ACL reconstruction in soccer athletes from the multicenter orthopaedic outcomes network (MOON) group. *Am J Sports Med*. 2012;40:2517–2522.
7. Mascarenhas R, Tranovich MJ, Kropf EJ, et al. Bone-patellar tendon-bone autograft versus hamstring autograft anterior cruciate ligament reconstruction in the young athlete: a retrospective matched analysis with 2-10 year follow-up. *Knee Surg Sports Traumatol Arthrosc*. 2012;20:1520–1527.
8. Nedeff DD, Bach BR Jr. Arthroscopic anterior cruciate ligament reconstruction using patellar tendon autografts. *Orthopedics*. 2002;25:343–357; quiz 358-349.
9. Chambat P, Guier C, Sonnery-Cottet B, et al. The evolution of ACL reconstruction over the last fifty years. *Int Orthop*. 2013;37:181–186.
10. Ardern CL, Webster KE, Taylor NF, et al. Return to sport following anterior cruciate ligament reconstruction surgery: a systematic review and meta-analysis of the state of play. *Br J Sports Med*. 2011;45:596–606.
11. Stergiou N, Ristanis S, Moraiti C, et al. Tibial rotation in anterior cruciate ligament (ACL)-deficient and ACL-reconstructed knees: a theoretical proposition for the development of osteoarthritis. *Sports Med*. 2007;37:601–613.
12. MacIntosh DLDT. Lateral substitution reconstruction. *J Bone Joint Surg*. 1976;58B:142.
13. Lemaire M. Ruptures anciennes du ligament croisé antérieur. *Chir (Paris)*. 1967;93:311–320.
14. Dejour H, Walch G, Neyret P, et al. Results of surgically treated chronic anterior laxities. Apropos of 251 cases reviewed with a minimum follow-up of 3 years. *Rev Chir Orthop Reparatrice Appar Mot*. 1988;74:622–636.
15. Noyes FR, Barber SD. The effect of an extra-articular procedure on allograft reconstructions for chronic ruptures of the anterior cruciate ligament. *J Bone Joint Surg Am*. 1991;73:882–892.
16. Marcacci M, Zaffagnini S, Giordano G, et al. Anterior cruciate ligament reconstruction associated with extra-articular tenodesis: A prospective clinical and radiographic evaluation with 10- to 13-year follow-up. *Am J Sports Med*. 2009;37:707–714.
17. O'Brien SJ, Warren RF, Pavlov H, et al. Reconstruction of the chronically insufficient anterior cruciate ligament with the central third of the patellar ligament. *J Bone Joint Surg Am*. 1991;73:278–286.
18. Strum GM, Fox JM, Ferkel RD, et al. Intraarticular versus intraarticular and extraarticular reconstruction for chronic anterior cruciate ligament instability. *Clin Orthop Relat Res*. 1989;245:188–198.
19. Acquitter Y, Hulet C, Locker B, et al. Patellar tendon-bone autograft reconstruction of the anterior cruciate ligament for advanced-stage chronic anterior laxity: is an extra-articular plasty necessary? A prospective randomized study of 100 patients with five year follow-up. *Rev Chir Orthop Reparatrice Appar Mot*. 2003;89:413–422.
20. Anderson AF, Snyder RB, Lipscomb AB Jr. Anterior cruciate ligament reconstruction. A prospective randomized study of three surgical methods. *Am J Sports Med*. 2001;29:272–279.

21. Claes S, Vereecke E, Maes M, et al. Anatomy of the anterolateral ligament of the knee. *J Anat*. 2013;223:321–328.
22. Vincent JP, Magnussen RA, Gezmez F, et al. The anterolateral ligament of the human knee: an anatomic and histologic study. *Knee Surg Sports Traumatol Arthrosc*. 2012;20:147–152.
23. Rasmussen MT, Nitri M, Williams BT, et al. An in vitro robotic assessment of the anterolateral ligament, part 1: secondary role of the anterolateral ligament in the setting of an anterior cruciate ligament injury. *Am J Sports Med*. 2016;44:585–592.
24. Kennedy MI, Claes S, Fuso FA, et al. The anterolateral ligament: an anatomic, radiographic, and biomechanical analysis. *Am J Sports Med*. 2015;43:1606–1615.
25. Monaco E, Ferretti A, Labianca L, et al. Navigated knee kinematics after cutting of the ACL and its secondary restraint. *Knee Surg Sports Traumatol Arthrosc*. 2012;20:870–877.
26. Parsons EM, Gee AO, Spiekerman C, et al. The biomechanical function of the anterolateral ligament of the knee. *Am J Sports Med*. 2015;43:669–674.
27. Sonnery-Cottet B, Saithna A, Cavalier M, et al. Anterolateral ligament reconstruction is associated with significantly reduced ACL graft rupture rates at a minimum follow-up of 2 Years: a prospective comparative study of 502 patients from the SANTI study group. *Am J Sports Med*. 2017;45:1547–1557.
28. Sonnery-Cottet B, Thaunat M, Freychet B, et al. Outcome of a combined anterior cruciate ligament and anterolateral ligament reconstruction technique with a minimum 2-year follow-up. *Am J Sports Med*. 2015;43:1598–1605.
29. Thaunat M, Clowez G, Saithna A, et al. Reoperation rates after combined anterior cruciate ligament and anterolateral ligament reconstruction: a series of 548 patients from the SANTI study group with a minimum follow-up of 2 years. *Am J Sports Med*. 2017;45:2569–2577.
30. Zhang H, Qiu M, Zhou A, et al. Anatomic anterolateral ligament reconstruction improves postoperative clinical outcomes combined with anatomic anterior cruciate ligament reconstruction. *J Sports Sci Med*. 2016;15:688–696.
31. Ibrahim SA, Shohdy EM, Marwan Y, et al. Anatomic reconstruction of the anterior cruciate ligament of the knee with or without reconstruction of the anterolateral ligament: a randomized clinical trial. *Am J Sports Med*. 2017;45:1558–1566.
32. Shah R, Singh R, Dugdale C, et al. Does additional reconstruction of the anterolateral ligament during a primary anterior cruciate ligament reconstruction affect tibial rotational laxity—a case series. *Ann Med Surg (Lond)*. 2017;19:7–18.
33. Sonnery-Cottet BS, Borade A, Ouanezar A, et al. Anterolateral ligament reconstruction protects the repaired medial meniscus: a comparative study of 383 acl reconstructions from the SANTI study group with a minimum follow up of two years. *Am J Sports Med*. 2018.
34. Mogos S, Sendrea B, Stoica IC. Combined anatomic anterior cruciate ligament and anterolateral ligament reconstruction. *Maedica (Buchar)*. 2017;12:30–35.
35. Sonnery-Cottet B, Daggett M, Helito CP, et al. Combined anterior cruciate ligament and anterolateral ligament reconstruction. *Arthrosc Tech*. 2016;5:e1253–e1259.
36. Roessler PP, Schuttler KF, Heyse TJ, et al. The anterolateral ligament (ALL) and its role in rotational extra-articular stability of the knee joint: a review of anatomy and surgical concepts. *Arch Orthop Trauma Surg*. 2016;136:305–313.
37. Sonnery-Cottet B, Lutz C, Daggett M, et al. The involvement of the anterolateral ligament in rotational control of the knee. *Am J Sports Med*. 2016;44:1209–1214.
38. Kartus J, Magnusson L, Stener S, et al. Complications following arthroscopic anterior cruciate ligament reconstruction. A 2-5-year follow-up of 604 patients with special emphasis on anterior knee pain. *Knee Surg Sports Traumatol Arthrosc*. 1999;7:2–8.
39. Hettrich CM, Dunn WR, Reinke EK, et al. The rate of subsequent surgery and predictors after anterior cruciate ligament reconstruction: two- and 6-year follow-up results from a multicenter cohort. *Am J Sports Med*. 2013;41:1534–1540.
40. Dodds AL, Gupte CM, Neyret P, et al. Extra-articular techniques in anterior cruciate ligament reconstruction: a literature review. *J Bone Joint Surg Br*. 2011;93:1440–1448.
41. Robb C, Kempshall P, Getgood A, et al. Meniscal integrity predicts laxity of anterior cruciate ligament reconstruction. *Knee Surg Sports Traumatol Arthrosc*. 2015;23:3683–3690.
42. Ardern CL, Taylor NF, Feller JA, et al. Fifty-five per cent return to competitive sport following anterior cruciate ligament reconstruction surgery: an updated systematic review and meta-analysis including aspects of physical functioning and contextual factors. *Br J Sports Med*. 2014;48:1543–1552.
43. McCullough KA, Phelps KD, Spindler KP, et al. Return to high school- and college-level football after anterior cruciate ligament reconstruction: a Multicenter Orthopaedic Outcomes Network (MOON) cohort study. *Am J Sports Med*. 2012;40:2523–2529.
44. Ferretti A, Monaco E, Fabbri M, et al. Prevalence and classification of injuries of anterolateral complex in acute anterior cruciate ligament tears. *Arthroscopy*. 2017;33:147–154.
45. Musahl V, Rahnemai-Azar AA, Costello J, et al. The influence of meniscal and anterolateral capsular injury on knee laxity in patients with anterior cruciate ligament injuries. *Am J Sports Med*. 2016;44:3126–3131.
46. Inderhaug E, Stephen JM, Williams A, et al. Anterolateral tenodesis or anterolateral ligament complex reconstruction: effect of flexion angle at graft fixation when combined with ACL reconstruction. *Am J Sports Med*. 2017;45:3089–3097.
47. Pearl AJ, Bergfeld JA. American Society for Sports Medicine Extraarticular reconstruction in the anterior cruciate ligament deficient knee. Champaign, Illinois: Human Kinetics; 1992.
48. Ferretti A. Extra-articular reconstruction in the anterior cruciate ligament deficient knee: a commentary. *Joints*. 2014;2:41–47.
49. Herbst E, Albers M, Burnham JM, et al. The anterolateral complex of the knee. *Orthop J Sports Med*. 2017;5:2325967117730805.
50. Marcacci M, Zaffagnini S, Iacono F, et al. Intra- and extra-articular anterior cruciate ligament reconstruction utilizing autogeneous semitendinosus and gracilis tendons: 5-year clinical results. *Knee Surg Sports Traumatol Arthrosc*. 2003;11:2–8.
51. Ferretti A, Monaco E, Ponzo A, et al. Combined intra-articular and extra-articular reconstruction in anterior cruciate ligament-deficient knee: 25 years later. *Arthroscopy*. 2016;32:2039–2047.
52. Claes S, Hermie L, Verdonk R, et al. Is osteoarthritis an inevitable consequence of anterior cruciate ligament reconstruction? A meta-analysis. *Knee Surg Sports Traumatol Arthrosc*. 2013;21:1967–1976.
53. Shelbourne KD, Benner RW, Gray T. Results of anterior cruciate ligament reconstruction with patellar tendon autografts: objective factors associated with the development of osteoarthritis at 20 to 33 years after surgery. *Am J Sports Med*. 2017;45:2730–2738.
54. Schon JM, Moatshe G, Brady AW, et al. Anatomic anterolateral ligament reconstruction of the knee leads to overconstraint at any fixation angle. *Am J Sports Med*. 2016;44:2546–2556.
55. Spencer L, Burkhart TA, Tran MN, et al. Biomechanical analysis of simulated clinical testing and reconstruction of the anterolateral ligament of the knee. *Am J Sports Med*. 2015;43:2189–2197.

56. Tavlo M, Eljaja S, Jensen JT, et al. The role of the anterolateral ligament in ACL insufficient and reconstructed knees on rotatory stability: a biomechanical study on human cadavers. *Scand J Med Sci Sports*. 2016;26:960–966.

57. Laffargue P, Delalande JL, Decoulx J. Reconstruction of the anterior cruciate ligament by bone-patellar tendon transplant. Evaluation of 79 cases. Prognostic factors. *Rev Chir Orthop Reparatrice Appar Mot*. 1997;83:505–514.

58. Musahl V, Getgood A, Neyret P, et al. Contributions of the anterolateral complex and the anterolateral ligament to rotatory knee stability in the setting of ACL injury: a roundtable discussion. *Knee Surg Sports Traumatol Arthrosc*. 2017;25:997–1008.

59. Sonnery-Cottet B, Daggett M, Fayard JM, et al. Anterolateral ligament expert group consensus paper on the management of internal rotation and instability of the anterior cruciate ligament—deficient knee. *J Orthop Traumatol*. 2017;18:91–106.

60. Daggett M, Ockuly AC, Cullen M, et al. Femoral origin of the anterolateral ligament: an anatomic analysis. *Arthroscopy*. 2016;32: 835–841.