Systematic Review

Long-Term Failure of Anterior Cruciate Ligament Reconstruction

S. Nicholas Crawford, M.D., MAJ Brian R. Waterman, M.D., MC, USA, and James H. Lubowitz, M.D.

Purpose: The aim of this study was to review and describe the cumulative incidence of anterior cruciate ligament (ACL) graft rupture and/or clinical objective failures at greater than 10 years after ACL reconstruction. **Methods:** A PubMed search was performed to identify and systematically evaluate all studies performed between 1980 and 2012 with clinical outcomes after intra-articular, non-artificial ACL reconstruction and minimum 10-year follow-up. Studies reporting standardized surgical technique, ACL graft rupture, and objective International Knee Documentation Committee (IKDC) grade or ligament stability examination were included for analysis. After we first identified patients with graft rupture, clinical failure was further identified as 1 or more of the following: overall IKDC objective score of C or D, IKDC grade C or D pivot shift (i.e., >2+ or pivot shift), IKDC grade C or D Lachman examination, and/or abnormal KT arthrometer (MEDmetric, San Diego, CA) measurement (i.e., >5 mm). For this study, cumulative ACL failure rates were defined as the sum of both clinical failures and ACL graft ruptures. **Results:** After review and exclusion of 625 references, 14 studies were identified for subsequent review. At longer than 10 years' clinical follow-up, the reported ACL graft rupture rate was 6.2% (173 of 2,782) (range, 0% to 13.4%) and clinical failure occurred in approximately 10.3% (158 of 1,532) (range, 1.9% to 25.6%). The overall cumulative ACL failure rate was 11.9% (range, 3.2% to 27%). **Conclusions:** At least 1 in 9 patients undergoing ACL reconstruction will have rerupture or clinical failure at long-term follow-up. **Level of Evidence:** Level IV, systematic review of Level II and IV studies.

Anterior cruciate ligament (ACL) reconstruction is 1 of the most commonly performed surgeries in orthopaedics.[1] Despite its prevalence and impact on patients' quality of life, the long-term outcomes of ACL reconstruction are poorly understood and have been inconsistently reported in the literature.[2] These studies vary widely in terms of quality, patient population, primary and secondary outcome measures, surgical techniques, and graft selection. Given this heterogeneity, it is difficult to extrapolate surgical outcomes of ACL reconstruction at a minimum of 10 years' clinical follow-up. Similarly, failure after ACL reconstruction lacks precision and requires more explicit definition. Although traumatic ACL rerupture can be easily identified, atraumatic or clinical failure can be attributed to a host of surgical and patient-specific factors, including nonanatomic tunnel placement, graft compromise, or inadequate rehabilitation.

Many longitudinal studies fail to account for failures related to poor subjective and/or objective patient outcomes, which could lead to an artificially low graft failure rate. This underscores the importance of sensitive, objective measures of graft laxity and ACL function, particularly instrumented or manual laxity measures and validated outcome measures such as the International Knee Documentation Committee (IKDC) score.[3]

Because of the rarity of long-term data on ACL reconstruction, systematic review may provide the best available evidence to guide contemporary treatment and prognosis. The aim of this study was to review and describe the cumulative incidence of ACL graft rupture and objective failures at greater than 10 years after ACL reconstruction. Our hypothesis was that ACL long-term clinical outcome data underestimate the true failure rate of ACL reconstruction.

From the Taos Orthopaedic Institute (S.N.C., J.H.L.), Taos, New Mexico; and the Department of Orthopaedic Surgery and Rehabilitation, William Beaumont Army Medical Center (B.R.W.), El Paso, Texas, U.S.A.

The authors report the following potential conflict of interest and sources of funding received in this article: J.H.L. is a consultant for Arthrex and Ivivi; paid speaker for DCI; receives royalties from Arthrex; holds stock in Ivivi; and has received research/institutional support from Arthrex, Breg, and Smith & Nephew.

Received January 24, 2013; accepted April 16, 2013.

Address correspondence to MAJ Brian R. Waterman, M.D., MC, USA, 5005 N Piedras St, El Paso, TX 79920-5001, U.S.A. E-mail: brian.r.waterman@us.army.mil

Published by Elsevier Inc. on behalf of the Arthroscopy Association of North America

0749-8063/1376/$00.00

http://dx.doi.org/10.1016/j.arthro.2013.04.014

Methods

A PubMed/Medline database search was performed in September 2011 and updated in December 2012 by use of the terms "anterior cruciate year follow" to evaluate failure rates of ACL reconstruction at greater than 10 years' follow-up. All citations were then screened by 2 investigators. Inclusion criteria required English-language publication, intra-articular allograft or autograft ACL reconstruction, consistent surgical technique, minimum 10-year follow-up, reported rerupture rate, and objective IKDC scoring and/or stability examination at final follow-up. Exclusion criteria included studies with extra-articular or tenodesis reconstructions, artificial graft sources, primary ACL repair, less than 10 years' follow-up, and/or systemic reviews or meta-analyses. If inclusion criteria were met or the abstract was not sufficient to determine inclusion, full review was performed.

Full review was performed to determine several parameters. Demographic characteristics, methodologic quality, timing of reconstruction, graft choice, surgical technique, coexisting pathology, subjective (e.g., Lysholm, Tegner) and objective outcome measures (e.g., Lachman test, instrumented laxity measures), and contralateral ACL rupture were identified. Furthermore, reported ACL rerupture were identified, objective clinical failure, and cumulative failure rates were extrapolated. For the purposes of this study, the clinical failure rate was defined, in cases exclusive of graft rupture, as one of the following: an overall IKDC objective score of C or D, IKDC grade C or D pivot shift (i.e., >2+ or pivot shift), IKDC grade C or D Lachman examination or KT arthrometer (MEDmetric, San Diego, CA) measurement (i.e., >5 mm), and/or identified grossly abnormal stability examination without IKDC scoring available. Finally, the redefined cumulative failure rate includes the sum of ACL rerupture plus clinical failure rates (adjusted for cohort size, as noted in the paragraph below).

The articles in this review excluded ACL graft ruptures, contralateral ACL injury, and incomplete outcome data in their reporting of subsequent objective clinical outcomes. As a result, clinical failure is identified among a smaller subset of patients who have achieved complete final follow-up with required objective clinical assessments. Conversely, rerupture rates were reported among the full patient cohort, thus accounting for differences in the denominator.

Results

After screening 625 results, we selected 26 studies for full review. Twelve of these were excluded because of surgical technique,[4-6] insufficient clinical follow-up,[7,8] absent or inadequate stability testing,[9-12] no reported rerupture rate,[13] non–English-language publication,[14] and inconsistent surgical technique.[15]

Data Extraction

A total of 14 studies were isolated for evaluation, including 8 retrospective series, 4 prospective series, 1 prospective comparative study, and 1 randomized controlled trial.[16-29] A total of 2,782 initial patients were evaluated for inclusion in this study, and 1,532 patients were isolated for full review at greater than 10 years' follow-up. Table 1 details the characteristics and study design of the included studies. Studies were analyzed for patient demographics, follow-up period, graft choice, allograft processing, femoral and tibial fixation, femoral tunnel drilling technique, contralateral ACL rupture, rerupture rate, return to previous sport/activity, 1-legged hop test, instrumented laxity measurement, range of motion, Lachman examination, pivot-shift testing, donor-site morbidity, period from injury to surgery, surgical complications, coexisting knee pathology (including chondral and meniscal lesions), concomitant knee procedures, and outcome measures (i.e., IKDC, Tegner, Lysholm, and visual analog scale scoring systems).

Graft Selection

Eleven studies used bone–patellar tendon–bone autografts,[17-20,22,23,25-29] including 2 prospective studies concomitantly evaluating hamstring autograft.[23,26] One retrospective study exclusively evaluated hamstring autograft.[21] Two additional studies used soft-tissue allograft (anterior tibialis, posterior tibialis, and/or Achilles tendon grafts). Nakata et al.[24] used non-irradiated allograft tissue with antibiotic treatment, whereas the sterilization methods were indeterminate for Almqvist et al.[16]

Surgical Technique

The surgical techniques, particularly femoral tunnel drilling and graft fixation, were variable among the included studies (Table 1). Of the studies, 9 involved tibial independent femoral tunnel drilling (7 transportal and 2 outside in), 3 used a transtibial technique, and 2 used unspecified techniques. Aperture interference screw fixation was the most common technique, but an implant-free press-fit technique, cross-pin fixation, suture anchor, screw post, and/or washer technique were also used.

ACL Failure

The ACL failure rates for the included studies are summarized in Table 2. The total ACL rerupture rate was 6.2% (173 of 2,782) (range, 0% to 13.4%). After application of our failure criteria, the clinical failure rate was 10.3% (158 of 1,532) (range, 1.9% to 25.6%). When taken in sum, the cumulative ACL failure rate at long-term follow-up increased to 11.9% (331 of 2,782) (range, 3.2% to 29.9%).

Discussion

This cumulative failure rate of primary ACL reconstruction may be higher than previously documented.

Table 1. Study Characteristics in Selected Studies

Study	Almqvist et al.[16]	Cohen et al.[17]	Felmet[18]	Hertel et al.[19]	Hui et al.[20]	Inderhaug et al.[21]	Lebel et al.[22]
Year	1995-1997	1986-1991	1998-1999	1987-1991	1993-1994	1999-2001	1993-1994
Mean follow-up (yr)	10.5	11.2	10.3	10.7	15.3	10.2	11.6
No. of patients (final follow-up/total consecutive patients)	50/60	62/126	148/189	95/159	72/333	80/96	101/272
Age (range) (yr)	25 (17-50)	27 (15-46)	38 (15-58)	42 (22-66)	26 (15-50)	25 (15-42)	29 (14-66)
Sex (% male)	72%	75.8%	61.5%	59.0%	51.1%	57.5%	76.5%
Methodology	Retrospective	Retrospective	Prospective	Retrospective	Retrospective	Retrospective	Prospective
Graft	Allograft PTT/ATT	Autograft BPTB	Autograft BPTB	Autograft BPTB	Autograft BPTB	Autograft 4HS	Autograft BPTB
Surgical technique	NP Suture anchors (F), IFS staple (T)	NP Screw washer (F/T)	TP Press fit (F/T)	TP Press fit (F/T) with or without cross-pin fixation (T)	TP IFS (F/T)	TT IFS (F) spiked washer screw (T)	TP IFS (F/T)
Reported outcomes	ROM, hop test, Biodex (Biodex Medical Systems, Shirley, NY), KT, Tegner, Lysholm, IKDC, XR	Lysholm, pivot, Lachman, KT, IKDC, XR	Lachman, pivot, Tegner, IKDC, XR	Tegner, Lysholm, IKDC, XR	Hop test, Lachman, pivot, KT, Lysholm, IKDC, XR	Lysholm, Lachman, pivot, KT, IKDC, Tegner, XR	IKDC, KT, XR, tunnel position
Level of evidence	IV	IV	IV	IV	IV	IV	IV

BPTB, bone—patella tendon—bone; F, femur; IFS, interference screw fixation; KT, instrumented knee laxity measures; NP, not provided; OI, outside-in; PTT/ATT, posterior tibialis and anterior tibialis tendon; ROM, range of motion; T, tibia; TP, transportal or independent femoral tunnel technique; TT, transtibial femoral tunnel technique; VAS, visual analog scale; XR, plain film radiographs; 4HS, quadruple-looped hamstring tendon.

Previous studies have focused on a limited description of failure after primary ACL reconstruction, reporting only on rates of ipsilateral ACL rerupture.[30] However, a more inclusive definition of ACL failure should encompass patients with poor clinical outcomes as indicated by established objective clinical measures. In this systematic review of 14 studies, ACL rerupture occurred in an average of 6.2% of patients at greater than 10 years' follow-up. Furthermore, when we considered additional objective failure criteria, the long-term, cumulative ACL failure rate nearly doubled to a rate of 11.9%.

In considering outcomes after ACL reconstruction, multiple primary and secondary endpoints may be considered. Foremost, rates of secondary ACL rupture are readily accessible from previous studies because this represents a discreet, yet variable measure of failure. In the included studies, the long-term rerupture rate varied between 0% and 13.4%, although short-term rerupture rates have been reported in up to 24.4% of high-demand, active patients receiving allograft reconstruction.[31] The risk of ACL graft failure may be highest in the first 2 years postoperatively, in part because of delayed biological incorporation associated with soft-tissue or allograft use. Bourke et al.[32] reported a 2.45% annual graft rupture rate within 2 years of surgery, but annual rates subsequently declined to 0.42% thereafter at up to 15 years' follow-up. Similarly, other studies have documented an annual rupture rate of 0.3% to 1.3%.[32]

In addition, a variety of objective knee outcome measures are currently in use, although they are not standardized across the literature. Among these, the IKDC scoring system remains 1 of the most commonly reported and is a comprehensive validated measure that includes objective assessments of range of motion, ligament stability, and radiographic findings. In their series of 133 patients, Irrgang et al.[3] showed the usefulness of the IKDC scoring system in describing

Table 1. Continued

Leys et al.[23]	Nakata et al.[24]	Oiestad et al.[25]	Sajovic et al.[26]	Salmon et al.[27]	Shelbourne and Gray[28]	van der Hart et al.[29]
1993-1994	1986-1990	1990-1997	1999-2000	1989	1982-1994	1993-1994
15	11.5	12.4	11	13	14.1	10.3
94/180	61/125	181/221	64/75	49/97	502/1,545	28/53
25 (15-42) 24 (13-52)	20.9 (NP)	39.5 (NP)	38 (27-58) 36 (25-54)	27 (25-28)	23.1 (11-53)	30.5 (16-42)
50.0%	42.6%	58.0%	56.9%	70.2%	72.0%	60.7%
Prospective comparative	Retrospective	Prospective	Randomized trial	Retrospective	Prospective	Retrospective
Autograft 4HS *v* BPTB	Non-irradiated soft tissue allograft	Autograft BPTB	Autograft BPTB *v* 4HS	Autograft BPTB	Autograft BPTB	Autograft BPTB
TP	2-incision OI Post/button (F/T)	TT NP	TP IFS (F/T)	TP Screw (F/T)	2-incision OI IFS (F/T)	TT IFS (F/T)
ROM, hop test, donor-site morbidity, Lachman, anterior drawer, pivot, KT, IKDC, Lysholm, VAS, XR, tunnel position	Strength, KT, XR	Strength, hop test, Lachman, pivot, KT, Cincinnati, VAS, Tegner, XR	Hop test, Lachman, pivot, KT, Lysholm, IKDC, XR	Hop test, Lachman, pivot, KT, IKDC, Lysholm, XR	Strength, ROM, hop test, pivot, KT, IKDC, Noyes, KT	VAS, Tegner, Lysholm, IKDC, XR
II	IV	II	II	IV	II	IV

outcomes after ACL reconstruction. After outcome analysis, 62% of the variability of the final IKDC rating was determined by the symptoms and laxity subgroup ratings,[3] underscoring the importance of long-term ACL stability. In our study, patients with an overall IKDC grade of C and D accounted for 10.3%, with rates ranging from 2% to 25.6%. However, this measure may represent a more stringent assessment of knee function compared with other instruments because the overall IKDC rating is defined by the lowest rating within each subgroup. As a result, this tool may be complemented by functional assessment scales in future studies to better evaluate return to sports or other routine daily activities.

Limitations

When ACL reruptures and objective clinical failures are collectively considered, the cumulative failure rate of primary ACL reconstruction after greater than 10 years' follow-up is nearly double that reported in the literature. However, as with any systematic review, we do acknowledge certain limitations within our study. Although strict inclusion criteria were used, our cumulative ACL failure rate did not account for functional or subjective outcome measures, such as the IKDC subjective form, Tegner score, and Lysholm score. These measures were inconsistently available, and subjective grading may be influenced on long-term follow-up by other pathologic processes both in and outside of the knee joint. As a result, our cumulative ACL failure rate may underestimate actual rates of long-term failure after ACL reconstruction. In addition, instrumented and manual laxity testing was not uniformly performed by a blinded examiner, which may introduce detection bias. Heterogeneity in patient demographics, surgical technique, tissue graft, and other study variables may also be considered. Lastly, differential losses to follow-up may contribute to selection bias, particularly when one considers the clinical outcomes in studies such as that of Shelbourne and Gray.[28] In this series of 1,545 patients, only 502 individuals completed final objective follow-up among 1,276 patients without postoperative ACL rupture. Further

Table 2. Long-Term Objective Clinical Outcomes in Selected Studies

	Stated Rerupture Rate	Abnormal Lachman	Abnormal Pivot Shift	Abnormal Instrumented Measures	IKDC Overall Grade C or D	Clinical Failure Rate	Redefined Cumulative Graft Failure Rate
Almqvist et al.[16]	4/55 (7.3%)	—	—	—	11/50 (22%)	11/50 (22%)	15/55 (27.3%)
Cohen et al.[17]	0/62 (0%)	7/62 (11.3%)	6/62 (9.7%)	5/62 (8.1%)	—	7/62 (11.3%)	7/62 (11.3%)
Felmet[18]	6/154 (3.9%)	—	4/148 (2.7%)	—	9/148 (6.1%)	9/148 (6.1%)	15/154 (9.7%)
Hertel et al.[19]	0/95 (0%)	—	3/95 (3.2%)	—	—	3/95 (3.2%)	3/95 (3.2%)
Hui et al.[20]	7/90 (7.2%)	7/72 (9.7%)	7/72 (9.7%)	—	10/72 (13.9%)	10/72 (13.9%)	17/90 (18.9%)
Inderhaug et al.[21]	3/83 (3.6%)	11/80 (14%)	16/80 (20%)	6/80 (8%)	—	16/80 (20%)	19/83 (22.9%)
Lebel et al.[22]	9/110 (8.2%)	9/101 (8.9%)	7/101 (6.9%)	2/101 (2.0%)	10/101 (9.9%)	10/101 (9.9%)	19/110 (17.3%)
Leys et al.[23]	22/180 (12.2%)	0/94 (0%)	0/94 (0%)	1/94 (2%)	1/94 (2%)	1/94 (2%)	23/180 (12.8%)
Nakata et al.[24]	3/68 (4.4%)	2/61 (3.3%)	4/61 (6.6%)	0/61 (0%)	—	4/61 (6.6%)	7/68 (10.3%)
Oiestad et al.[25]	15/181 (8.3%)	23/144 (16.0%)	17/144 (11.8%)	—	—	23/144 (16.0%)	38/181 (21.0%)
Sajovic et al.[26]	5/64 (7.8%)	1/52 (1.9%)	1/52 (1.9%)	1/52 (1.9%)	—	1/52 (1.9%)	6/64 (9.4%)
Salmon et al.[27]	9/67 (13.4%)	3/43 (7.0%)	0/43 (0%)	3/35 (8.6%)	11/43 (25.6%)	11/43 (25.6%)	20/67 (29.9%)
Shelbourne and Gray[28]	90/1,545 (5.8%)	—	5/502 (1.0%)	15/502 (3.0%)	48/502 (9.6%)	48/502 (9.6%)	138/1,545 (8.9%)
van der Hart et al.[29]	0/28 (0%)	—	—	4/28 (14.3%)	4/28 (14.3%)	4/28 (14.3%)	4/28 (14.3%)
Total	173/2,782 (6.2%)					158/1,532 (10.3%)	331/2,782 (11.9%)

emphasis on standardized study design and comprehensive patient follow-up may obviate these issues in future studies.

Conclusions

At least 1 in 9 patients undergoing ACL reconstruction will have rerupture or clinical failure at long-term follow-up.

References

1. Lubowitz JH, Appleby D. Cost-effectiveness analysis of the most common orthopaedic surgery procedures: Knee arthroscopy and knee anterior cruciate ligament reconstruction. *Arthroscopy* 2011;27:1317-1322.
2. Oiestad BE, Engebretsen L, Storheim K, Risberg MA. Knee osteoarthritis after anterior cruciate ligament injury: A systematic review. *Am J Sports Med* 2009;37:1434-1443.
3. Irrgang JJ, Ho H, Harner CD, Fu FH. Use of the International Knee Documentation Committee guidelines to assess outcome following anterior cruciate ligament reconstruction. *Knee Surg Sports Traumatol Arthrosc* 1998;6:107-114.
4. Marcacci M, Zaffagnini S, Giordano G, Iacono F, Presti ML. 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.
5. Pernin J, Verdonk P, Si Selmi TA, Massin P, Neyret P. Long-term follow-up of 24.5 years after intra-articular anterior cruciate ligament reconstruction with lateral extra-articular augmentation. *Am J Sports Med* 2010;38:1094-1102.
6. Yamaguchi S, Sasho T, Tsuchiya A, Wada Y, Moriya H. Long term results of anterior cruciate ligament reconstruction with iliotibial tract: 6-, 13-, and 24-year longitudinal follow-up. *Knee Surg Sports Traumatol Arthrosc* 2006;14:1094-1100.
7. Kessler MA, Behrend H, Henz S, Stutz G, Rukavina A, Kuster MS. Function, osteoarthritis and activity after ACL-rupture: 11 years follow-up results of conservative versus reconstructive treatment. *Knee Surg Sports Traumatol Arthrosc* 2008;16:442-448.
8. Shelbourne KD, Benner RW. Isolated anterior cruciate ligament reconstruction in the chronic ACL-deficient knee with degenerative medial arthrosis. *J Knee Surg* 2007;20:216-222.
9. Holm I, Oiestad BE, Risberg MA, Aune AK. No difference in knee function or prevalence of osteoarthritis after reconstruction of the anterior cruciate ligament with 4-strand hamstring autograft versus patellar tendon-bone autograft: A randomized study with 10-year follow-up. *Am J Sports Med* 2010;38:448-454.
10. Meuffels DE, Favejee MM, Vissers MM, Heijboer MP, Reijman M, Verhaar JA. Ten year follow-up study comparing conservative versus operative treatment of anterior cruciate ligament ruptures. A matched-pair analysis of high level athletes. *Br J Sports Med* 2009;43:347-351.
11. Moller E, Weidenhielm L, Werner S. Outcome and knee-related quality of life after anterior cruciate ligament

reconstruction: A long-term follow-up. *Knee Surg Sports Traumatol Arthrosc* 2009;17:786-794.
12. Oiestad BE, Holm I, Engebretsen L, Risberg MA. The association between radiographic knee osteoarthritis and knee symptoms, function and quality of life 10-15 years after anterior cruciate ligament reconstruction. *Br J Sports Med* 2011;45:583-588.
13. Janssen RP, du Mée AW, van Valkenburg J, Sala HA, Tseng CM. Anterior cruciate ligament reconstruction with 4-strand hamstring autograft and accelerated rehabilitation: A 10-year prospective study on clinical results, knee osteoarthritis, and its predictors. *Knee Surg Sports Traumatol Arthrosc*. 19 October, 2012. [Epub ahead of print.]
14. Jager A, Welsch F, Braune C, Eberhardt C, Kappler C. Ten year follow-up after single incision anterior cruciate ligament reconstruction using patellar tendon autograft. *Z Orthop Ihre Grenzgeb* 2003;141:42-47 (in German).
15. Drogset JO, Grontvedt T, Robak OR, Molster A, Viset AT, Engebretsen L. A sixteen-year follow-up of three operative techniques for the treatment of acute ruptures of the anterior cruciate ligament. *J Bone Joint Surg Am* 2006;88: 944-952.
16. Almqvist KF, Willaert P, De Brabandere S, Criel K, Verdonk R. A long-term study of anterior cruciate ligament allograft reconstruction. *Knee Surg Sports Traumatol Arthrosc* 2009;17:818-822.
17. Cohen M, Amaro JT, Ejnisman B, et al. Anterior cruciate ligament reconstruction after 10 to 15 years: Association between meniscectomy and osteoarthrosis. *Arthroscopy* 2007;23:629-634.
18. Felmet G. Implant-free press-fit fixation for bone-patellar tendon-bone ACL reconstruction: 10-year results. *Arch Orthop Trauma Surg* 2010;130:985-992.
19. Hertel P, Behrend H, Cierpinski T, Musahl V, Widjaja G. ACL reconstruction using bone–patellar tendon–bone press-fit fixation: 10-year clinical results. *Knee Surg Sports Traumatol Arthrosc* 2005;13:248-255.
20. Hui C, Salmon LJ, Kok A, Maeno S, Linklater J, Pinczewski LA. Fifteen-year outcome of endoscopic anterior cruciate ligament reconstruction with patellar tendon autograft for "isolated" anterior cruciate ligament tear. *Am J Sports Med* 2011;39:89-98.
21. Inderhaug E, Strand T, Fischer-Bredenbeck C, Solheim E. Long-term results after reconstruction of the ACL with hamstrings autograft and transtibial femoral drilling. *Knee Surg Sports Traumatol Arthrosc*. 8 December, 2012. [Epub ahead of print.]
22. Lebel B, Hulet C, Galaud B, Burdin G, Locker B, Vielpeau C. Arthroscopic reconstruction of the anterior cruciate ligament using bone-patellar tendon-bone autograft: A minimum 10-year follow-up. *Am J Sports Med* 2008;36:1275-1282.
23. Leys T, Salmon L, Waller A, Linklater J, Pinczewski L. Clinical results and risk factors for reinjury 15 years after anterior cruciate ligament reconstruction: A prospective study of hamstring and patellar tendon grafts. *Am J Sports Med* 2012;40:595-605.
24. Nakata K, Shino K, Horibe S, et al. Arthroscopic anterior cruciate ligament reconstruction using fresh-frozen bone plug-free allogeneic tendons: 10-year follow-up. *Arthroscopy* 2008;24:285-291.
25. Oiestad BE, Holm I, Aune AK, et al. Knee function and prevalence of knee osteoarthritis after anterior cruciate ligament reconstruction: A prospective study with 10 to 15 years of follow-up. *Am J Sports Med* 2010;38:2201-2210.
26. Sajovic M, Strahovnik A, Dernovsek MZ, Skaza K. Quality of life and clinical outcome comparison of semitendinosus and gracilis tendon versus patellar tendon autografts for anterior cruciate ligament reconstruction: An 11-year follow-up of a randomized controlled trial. *Am J Sports Med* 2011;39:2161-2169.
27. Salmon LJ, Russell VJ, Refshauge K, et al. Long-term outcome of endoscopic anterior cruciate ligament reconstruction with patellar tendon autograft: Minimum 13-year review. *Am J Sports Med* 2006;34:721-732.
28. Shelbourne KD, Gray T. Minimum 10-year results after anterior cruciate ligament reconstruction: How the loss of normal knee motion compounds other factors related to the development of osteoarthritis after surgery. *Am J Sports Med* 2009;37:471-480.
29. van der Hart CP, van den Bekerom MP, Patt TW. The occurrence of osteoarthritis at a minimum of ten years after reconstruction of the anterior cruciate ligament. *J Orthop Surg Res* 2008;3:24.
30. Wright RW, Magnussen RA, Dunn WR, Spindler KP. Ipsilateral graft and contralateral rupture at five years or more following ACL reconstruction: A systematic review. *J Bone Joint Surg Am* 2011;93:1159-1165.
31. Barrett GR, Luber K, Replogie WH, Manley JL. Allograft anterior cruciate ligament reconstruction in the young, active patient: Tegner activity level and failure rate. *Arthroscopy* 2010;26:1593-1601.
32. Bourke HE, Salmont LJ, Waller A, Patterson V, Pinczewski LA. Survival of the anterior cruciate ligament graft and the contralateral ACL at a minimum of 15 years. *Am J Sports Med* 2012;40:1985-1992.