J Orthopaed Traumatol (2006) 7:103–107
DOI 10.1007/s10195-006-0131-z

V. Calvisi
S. Lupparelli
R. Padua

Patellar tendon autograft versus hamstring tendon autograft in arthroscopic anterior cruciate ligament reconstruction: appraisal of the evidence

Received: 6 April 2006
Accepted: 15 May 2006
Published online: 20 June 2006

V. Calvisi (✉) • S. Lupparelli
Unit of Motorial Diseases
Department of Surgery
University of Aquila
L'Aquila, Italy
E-mail: calvisiv@libero.it

R. Padua
San Giacomo Hospital
Globe
Rome, Italy

Abstract Arthroscopy-assisted reconstruction of a torn anterior cruciate ligament (ACL) is a commonly performed surgical procedure. The type of graft used for ACL reconstruction has traditionally been an autograft; the more commonly used grafts are the bone-patellar tendon-bone (BPTP) and hamstring tendons, namely the gracilis and semitendinosus tendons (GST). We surveyed the evidence concerning the outcome of patients treated by arthroscopic reconstruction of the ACL with either BPTP or GST. On basis of several well-designed studies, specifically 5 meta-analyses and one systematic review, we critically discuss the best evidence available today regarding ACL reconstruction. This evidence suggests that BPTP may be considered for patients performing high-demand activities not involving repetitive kneeling.

Key words Anterior cruciate ligament • Autograft reconstruction • Knee arthroscopy • Systematic review • Meta-analysis • EBM

Introduction

Arthroscopically assisted reconstruction of a torn anterior cruciate ligament (ACL) is a commonly performed surgical procedure owing to the widespread engagement of the population in sports activities, at both amateur and professional levels. Indications for ACL reconstruction include symptomatic knee instability despite an appropriate rehabilitation program in patients who are unable or do not wish to modify their activity levels and lifestyles. Potential candidates are also those who did not benefit from modifications in activities and lifestyles nor from a well-conducted rehabilitation program. The rationale underlying ACL reconstruction is a decreased risk of joint derangement secondary to progressive cartilage and meniscal damage caused by repeated episodes of instability [1]. However, it has not been conclusively demonstrated that ACL reconstruction alters the natural history of an ACL-deprived knee joint [1].

The type of graft used in ACL reconstruction has traditionally been an autograft, although recent research suggests that allografts may be an acceptable alternative despite the apparently slower rate of incorporation [2]. Among autografts, the bone-patellar tendon-bone (BPTP) graft has been extensively used and has so far represented the gold standard. BPTP testing has in fact shown that its mechanical properties and biology of incorporation satisfy the biomechanical requirements for returning patients to their pre-injury levels of activity. However, harvesting BPTB may be associated with complications such as patellar fractures and with subsequent donor site morbidity. The use of the hamstring tendons (HT), namely the gracilis and semitendinosus tendons (GST), has been consequently advocated as a viable alternative to BPTP in order to avoid BPTP-related complications and morbidity. Initial concerns over the mechanical strength of the GST have subsequently subsided as biomechanical testing has shown that the GST's mechanical properties warrant its use for ACL reconstruction. Biomechanical studies have

also indicated that the mechanical strength varies as a function of the type of construct assembled by the GSTs, which may be double, triple or quadruple. Weakness of the ischiocrural muscles in patients undergoing ACL reconstruction with GSTs has been reported [1, 2].

In addition to testing the mechanical strength of the autograft, it should be considered that either autograft presents particular features with reference to the biology of graft incorporation, the modality of graft fixation and its performance in vivo. Notably, the different modalities of osteointegration, with a bone-to-bone interface and a tendon-to-bone interface in the cases of BPTP and GST, respectively, may affect knee stability in the middle and long terms. Likewise, the risk of tunnel enlargement may differ when using either autograft, which in turn may affect knee stability [1, 2]. Although biomechanical and basic science research represents the prerequisite for the introduction of new surgical techniques, the actual performance in vivo and the relevant clinical outcomes are ultimately assessed by clinical research. Particularly, randomised controlled trials (RCTs), systematic reviews and meta-analyses, when available, are thought to offer the best evidence to help surgeons choose the most suitable graft for ACL reconstruction. Therefore, we surveyed the evidence concerned with the outcome of patients treated by arthroscopic reconstruction of the ACL with either BPTP or GST.

Materials and methods

A bibliografic search was conducted using the most representative databases available. We search for meta-analyses, systematic reviews, guidelines and randomized controlled trials (RCT's) which compare two or more techniques of ACL reconstruction. Our search strategies included the following database: Cochrane Musculoskeletal Injuries Group specialised register, the Cochrane Central Register of Controlled Trials, Health Technology Assessment (HTA), PEDro, MEDLINE, EMBASE, CINAHL, AMED, DARE, TRIP, the National Research Register (UK). The search was completed in May 2006. The following search terms selected from The National Library of Medicine's medical subject heading (MESH) database, were: human; anterior cruciate ligament; knee.

One systematic review [3] and five meta-analyses [4–8] comparing the use of BPTB and HTs in arthroscopic ACL reconstruction have already been published. Two meta-analyses were published in 2001 and 2003, the systematic review in 2004, two other meta-analyses in 2005 and the latest meta-analysis in 2006. Additionally, we performed a manual search to find RCTs and quasi-RCTs published in the *Giornale Italiano di Ortopedia e Traumatologia* and in the *Journal of Orthopaedics and Traumatology,* available through the Web site (www.siot.it), from 15 May 2005 to 30 April 2006.

The quality of the systematic review and of the meta-analyses as well of any additional paper published thereafter was assessed by two of the authors of the present study (S.L. and R.P.). The retrieved studies were included provided they conveyed information about both subjective and objective outcomes. Conclusions reached in the meta-analyses and in the systematic review were chronologically appraised in order to evaluate whether the available evidence changed over the time span from 2001 to 2006. RCTs and quasi-RCTs published after 15 May 2005 were also screened for their methodological quality before being included in the present study.

Results

Regarding articles published after the 2006 meta-analysis, we found one RCT published in February 2006 [9]. Unfortunately, the randomisation method used and fact that the paper did not provide information on how patients and physicians involved in the study were blinded to the administered treatments were not in compliance with the recommendations established in the *Cochrane Handbook for Systematic Review of Interventions* (ver. 4.2.5.) [10]. The RCT was accordingly not included in the present analysis. Of the five meta-analyses retrieved from the literature, the one published by Prodromos and coworkers [7] was also not included in the present analysis as it focused uniquely on objective outcome measures (instrumented laxity) and modality of fixation.

The meta-analysis by Yunes and coworkers published in 2001 (Table 1) [4] included only English language articles published from January 1980 to May 1997, with a minimum follow-up of 24 months. The inclusion criteria restricted the choice of papers to RCTs and quasi-RCTs. A total of four studies reporting the outcomes following ACL reconstruction with BPTP and HTs was selected. The end-points considered for outcome assessment were: return to preinjury level of activity; static stability as assessed by physical findings (Lachman and pivot-shift tests) and KT-1000 arthrometer; range of motion (ROM); complications and failures. The conclusions reached by Yunes et al. were that patients whose torn ACL was reconstructed with a BPTB had a significantly greater chance of achieving static stability of the knee (as measured by KT-1000 arthrometer) and a 20% higher probability of returning to their preinjury level of activity.

The meta-analysis by Freedman and coworkers published in 2003 [5] included only English language articles published from January 1966 to May 2000, with a minimum follow-up of 24 months. The inclusion criteria did not restrict the selection of studies to RCTs and quasi-RCTs. The meta-analysis, therefore, included 21 and 13 studies concerned with ACL reconstruction with BPTP

Table 1 The main features of the systematic review and meta-analyses included in the present studies are summarized

Authors	Type of study	Publication date	Time span of article retrieval	Type of studies included	Number of studies included	Article language	Follow-up	End points for outcome assessment
Yunes M et al. [4]	MA	2001	January 1980- May 1997	RCTs and quasi-RCTs	4	English	Minimum 24 months	Manual and instrumented laxity; ROM; Return to preinjury level; Complications; Failures
Freedman KB et al [5]	MA	2003	January 1966- May 2000	Controlled and uncontrolled trials	34	English	Minimum 24 months	Manual and instrumented laxity; ROM; Return to sports; Patients' satisfaction; Patellofemoral pain Complications; Failures
Spindler KP et al. [3]	SR	2004	January 1966 - December 2003	RCTs	9	English	Minimum 24 months	Surgical technique; Rehabilitation protocol; Manual and instrumented laxity; ROM; Isokinetic strength; Patient-based outcome tools Return to preinjury level; Patients' satisfaction; Patellofemoral pain Complications; Revision surgery; Failures
Goldblatt JP et al. [6]	MA	2005	January 1966 - April 2003	RCTs and prospective studies	11	English	Minimum 24 months	Manual and instrumented laxity; ROM; Kneeling pain
Biau DJ et al. [8]	MA	2006	?- 14 March 2005	RCTs and quasi-RCTs	24	All	Mean 12 months	Manual and instrumented laxity; ROM; Anterior knee pain Kneeling pain; Failures

RS, systematic review; *MA*, meta-analysis

and HTs, respectively. The following end-points were used to assess outcome differences between the groups: graft failure and postoperative laxity; patient satisfaction and return to sports; ROM; patellofemoral pain; and complications. Comparison between the two groups revealed that patients undergoing ACL reconstruction with BPTP had a significantly lower rate of graft failure, higher static stability, higher satisfaction and lower rate of hardware removal. Conversely, patients undergoing ACL reconstruction with HTs had a significantly lower rate of manipulation under anaesthesia and lysis of adherences and a lower prevalence of anterior knee pain.

The systematic review by Spindler and coworkers issued in 2004 [3] comprised only English language articles published from January 1966 to December 2003, with a minimum follow-up of 24 months. The inclusion criteria restricted the selection of articles to RCTs, of which nine were included in the analysis. The variables for outcome assessment were: surgical technique (modality of harvesting, type of construct in the case of HTs and type of fixation); rehabilitation protocol; return to preinjury level of activity; instrumented laxity; isokinetic strength; patellofemoral pain; Tegner, Lysholm, Cincinnati and International Knee Documentation Committee-1991 scores; ROM; graft failure; ACL revision surgery; and complications. The authors concluded that patients who underwent ACL reconstruction with BPTB had increased knee pain with kneeling in four of four studies, although only one of nine studies indicated increased anterior knee pain. Moreover, instrumented laxity was apparently greater when HTs were used as autografts. Revision surgery was related to the type of fixation and not to the type of autograft. No other subjective or objective variable differed significantly between the groups. The authors concluded that the type of autograft may not be the primary determinant for a successful arthroscopic ACL reconstruction.

The meta-analysis by Goldblatt and coworkers published in 2005 [6] included only English language articles published from January 1966 to April 2003, with a minimum follow-up of 24 months. All patients entered the same rehabilitation protocol after surgery. RCTs and prospective studies were included in the meta-analysis. Eleven papers fulfilled the criteria for inclusion. The end-points assessed were: manual (Lachman and pivot-shift tests) and instrumented (KT-1000) laxity; patellofemoral crepitation; kneeling pain; and ROM. The authors found that the prevalence of knee instability (as defined by a Lachman test grade 2, pivot-shift test grade 2 or KT-1000 manual-maximum side-to-side difference >5 mm) was significantly different between the BPTP and HTs (three or four strand graft) groups. However, patients in the BPTP group were more likely to have normal results on the Lachman and pivot-shift tests, a KT-1000 manual-maximum side-to-side difference < 3 mm and less flexion loss. On the other hand, patients reconstructed with HTs had less femoropatellar crepitation, kneeling pain and extension loss. The authors concluded that the choice of autograft should be individualised and discussed with the patient.

Finally, the meta-analysis by Biau and coworkers published in 2006 [8] included articles published up to 14 March 2005, with a mean follow-up of one year. No language restrictions were applied. Only RCTs and quasi-RCTs were included in the analysis. Twenty-four studies satisfied the inclusion criteria. The end-points for outcome assessment were: manual (Lachman and pivot-shift tests) and instrumented (KT-1000) stability; ROM; anterior knee pain and kneeling pain; and graft failure. Comparison between the two groups revealed that patients who underwent ACL reconstruction with BPTP had more anterior knee symptoms and extension deficit than patients reconstructed with HTs. Evidence that patellar tendon yields better knee stability was weak. The BPTP and four-strand HT constructs had similar stability. The authors' conclusions were that the choice of autograft should be thoroughly discussed with the patient on the basis of the scientific evidence.

Discussion

The importance of RCTs within the framework are of evidence-based research is that, by random allocation, each patient has an equal chance of being given each treatment; this is the most effective way of preventing bias in research [11]. Unfortunately, objective difficulties exist in performing randomized trials in surgery [12] and RCTs often conducted on relatively small samples. Systematic reviews and meta-analyses are powerful tools for overcoming the limitations of studies based on small samples by pooling data from published RCTs and summarizing current evidence, if any, on a specific topic. It should be highlighted, however, that the quality of systematic reviews and of meta-analyses is affected by the quality of the studies selected for inclusion [13]. Readers should accordingly interpret the evidence condensed in such potentially powerful tools as well appraise the methodology underlying the selection of studies included for analysis.

Our literature search aimed to provide readers with an EBM-oriented state-of-the art analysis about the ongoing debate as to the type of autograft to be used for ACL reconstruction. The increasing awareness and widespread acceptance of the role of EBM in research in the scientific community over the last years has led to the publication of a suitable number of studies to be included in one systematic review and the four meta-analyses issued from 2001 to date.

The evidence yielded by the systematic review and the four meta-analyses shows that the conclusions reached in each paper are not wholly consistent. One might assume that, as more studies are published and included in meta-analyses and systematic reviews, the conclusions are subsequently modified and updated. However, it should be noted that the authors of each survey adopted different inclusion criteria, e.g. type of study, language of publication, follow-up time, type of HT construct, type of rehabilitation (Table 1). Therefore, stating that the *latest* meta-analysis conveys more updated information derived from a higher number of studies than the previous ones would be erroneous.

Despite these limitations, the following considerations may be made from the evidence available at the present time. We believe they may help orthopaedic surgeons choose the best type of autograft for each patient. The first is that initial concerns over the mechanical strength of the HT construct seem not to be warranted. Although only the systematic review by Spindler et al. [3] clearly stratified studies in relation to the type of HT construct used, on the whole the HT autograft would be able to restore knee stability. It is as well true that manual and instrumented tests indicated that the BPTP graft was more effective in reducing static instability in some studies, yet the relevant evidence is weak. The second is that no conclusive evidence exists regarding whether graft failure and revision surgery are related to the type of autograft. Although the meta-analysis by Freedman et al. [5] suggested that the rate of graft failure is higher in patients reconstructed with HTs, the systematic review by Spindler et al. [3] related failure to the type of fixation used. The third is that all studies supplied evidence that anterior knee symptoms are far more prevalent in patients reconstructed with BPTP.

In summary, current evidence suggests avoiding the use of BPTP in patients involved in repetitive kneeling activities. If stability is the main concern, the BPTP may be considered in patients performing high-demand activities not involving repetitive kneeling. Patients should be thoroughly informed about the evidence supporting the surgeon's choice of the type of autograft. Further high-quality RTCs and relevant meta-analyses with strict inclusion criteria comprehensively stratifying the variables of interest are required to provide additional evidence on the choice of type of graft.

Conflict of interests disclosure: No funds were received in support of this work. No benefits in any form have been or will be received from a commercial party related directly or indirectly to the subject of this manuscript.

References

1. Beynnon BD, Johnson RJ, Abate JA, Fleming BC, Nichols CE (2005) Treatment of anterior cruciate ligament injuries, Part I. Am J Sports Med 33:1579–1602
2. Beynnon BD, Johnson RJ, Abate JA, Fleming BC, Nichols CE (2005) Treatment of anterior cruciate ligament injuries, Part II. Am J Sports Med 33:1751–1767
3. Spindler KP, Khun JE, Freedman KB, Matthews CE, Dittus RS, Harrel FE (2004) Anterior cruciate ligament reconstruction autograft: bone-tendon-bone versus hamstring. Does it really matter? A systematic review. Am J Sports Med 32:1986–1995
4. Yunes M, Richmond JC, Engels EA, Pinczewski LA (2001) Patellar versus hamstring tendons in anterior cruciate ligament reconstruction: a meta-analysis. Arthroscopy 17:248–257
5. Freedman KB, D'Amato MJ, Nedeff DD, Kaz A, Bach BR (2003) Arthroscopic anterior cruciate ligament reconstruction: a meta-analysis comparing patellar tendon and hamstring tendon autograft. Am J Sports Med 31:2–11
6. Goldblatt JP, Fitzsimmons SE, Balk E, Richmond JC (2005) Reconstruction of the anterior cruciate ligament: meta-analysis of the patellar tendon versus hamstring tendon autograft. Arthroscopy 21:791–803
7. Prodromos CC, Joyce BT, Shi K, Keller BL (2005) A meta-analysis of stability after anterior cruciate ligament reconstruction as a function of hamstring versus patellar tendon graft and fixation type. Arthroscopy 21:1202
8. Biau DJ, Tournoux C, Katsahian S, Schranz PJ, Nizard RS (2006) Bone-patellar tendon-bone autograft versus hamstring autograft for reconstruction of anterior cruciate ligament: meta-analysis. BMJ 332:998–1003
9. Matsumoto A, Yoshiya S, Muratsu H, Yagi M, Iwasaki Y, Kurosaka M, Kuroda R (2006) A comparison of bone-patellar tendon-bone and bone-hamstring tendon-bone autografts for anterior cruciate ligament reconstruction. Am J Sports Med 34:213–219
10. Cochrane Handbook for Systematic Reviews of Interventions (ver. 4.2.5, May 2005 http://www.cochrane.org/resources/handbook/handbook.pdf
11. Altman DG (1991) Designing research. In: Altman DG (ed) Practical statistics for medical research. Chapman and Hall, London, pp 74–106
12. McCulloch P, Taylor P, Sasako M, Lovett B, Griffin D (2002) Randomised trials in surgery: problems and possible solutions. BMJ 324:1448–1451
13. Bhandari M, Morrow F, Kulkarni AV, Tornetta P III (2001) Meta-analysis in orthopaedic surgery. A systematic review of their methodologies. J Bone Joint Surg Am 83:15–24