

## Systematic Review

# Is There a Higher Failure Rate of Allografts Compared With Autografts in Anterior Cruciate Ligament Reconstruction: A Systematic Review of Overlapping Meta-analyses

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**Purpose:** Multiple meta-analyses of randomized controlled trials (RCTs), the highest available level of evidence, have been conducted to determine whether autograft or allograft tissue provides superior clinical outcomes and structural healing in anterior cruciate ligament reconstruction (ACLR); however, results are discordant. The purpose of this study was to conduct a systematic review of meta-analyses comparing ACLR with autografts and allografts to elucidate the cause of discordance and to determine which meta-analyses provide the current best available evidence. **Methods:** In this study we evaluated available scientific support for autograft versus allograft use in ACLR by systematically reviewing the literature for published meta-analyses. Data regarding patient outcomes and structural healing were extracted from these meta-analyses. Meta-analysis quality was assessed using the Oxman-Guyatt and Quality of Reporting of Meta-analyses (QUOROM) systems. The Jadad algorithm was then applied to determine which meta-analyses provided the highest level of evidence. **Results:** Eight meta-analyses containing a total of 15,819 patients met the eligibility criteria, 2 of which included Level II evidence and 6 of which included Level III/IV evidence. Four meta-analyses found no differences between autografts and allografts for patient outcomes, whereas 4 found autografts superior in one or more respects. Four meta-analyses reported higher graft rupture rates in the allograft group, and 2 found superior hop test performance in autograft-treated patients. Six meta-analyses had low Oxman-Guyatt scores (<4) indicative of major flaws. **Conclusions:** According to this systematic review of overlapping meta-analyses comparing autografts and allografts for ACLR, the current best available evidence suggests no differences in rupture rates and clinical outcomes. Lower quality meta-analyses indicate that autografts may provide a lower rerupture rate, better hop test performance, and better objective knee stability than do allografts. **Level of Evidence:** systematic review of Level II, III, and IV meta-analyses.

Anterior cruciate ligament (ACL) injuries are among the most common conditions faced by the practicing orthopaedic surgeon.<sup>1</sup> It is estimated that there are more than 250,000 ACL injuries in the United States annually, more than half of which undergo reconstruction.<sup>2-4</sup> Although ACL reconstruction (ACLR) has become the standard of care in young athletes, the optimal graft choice between allografts and autografts has not been clearly elucidated.<sup>5</sup>

A number of clinical studies and meta-analyses have shown a significant difference, favoring autografts over allografts.<sup>6-8</sup> Li et al.<sup>5</sup> showed that after ACLR, autograft tissue appears to mature faster than allograft tissue on magnetic resonance imaging. However, this study found no clinically significant differences between allografts and autografts, and both cohorts of patients returned to normal sporting activities at similar intervals. Furthermore, several studies and

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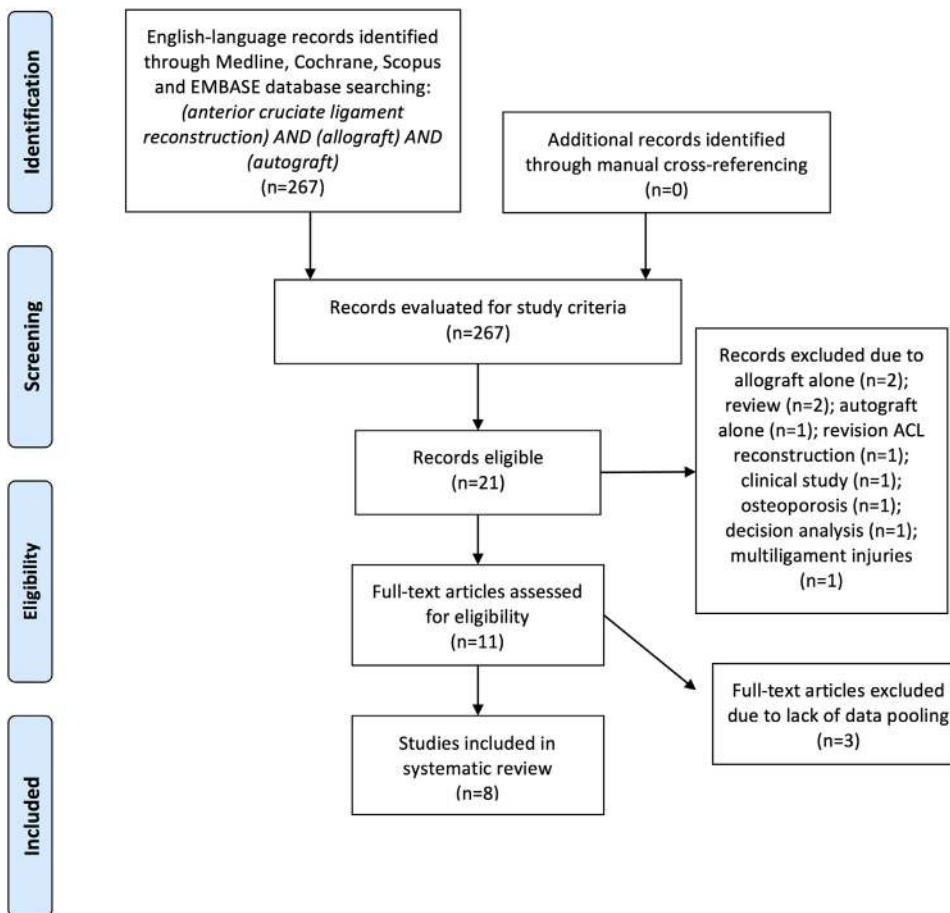
Linvatec, DJ Orthopaedics, Ossur, Smith & Nephew, and Tornier. Study performed at Rush University Medical Center.

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**Fig 1.** Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) flow diagram showing application of the study algorithm, including the number of studies excluded at each stage in relation to the eligibility criteria.

reviews have found no significant differences between autografts and allografts.<sup>9-11</sup> For instance, Sun et al.<sup>12</sup> conducted a long-term randomized controlled trial (RCT) comparing quadrupled hamstring tendon autografts and fresh-frozen hamstring allografts. After a mean 7.8-year follow-up period, there were no significant differences in the International Knee Documentation Committee (IKDC), Lysholm, Cincinnati, and Tegner scores between the 2 graft types. The discrepancy in the results of these clinical studies and meta-analyses has likely prevented the development of a consensus regarding autograft versus allograft use in ACLR and complicates interpretation of the literature on this topic by orthopaedic surgeons treating these patients.

Therefore, the purpose of this study was to conduct a systematic review of overlapping meta-analyses comparing ACLR with autografts and ACLR with allografts to elucidate the cause of discordance and to determine which meta-analyses provide the current best available evidence on the topic.

In the context of this study, meta-analyses were defined as studies that performed quantitative synthesis of data from multiple clinical studies that

compared autograft versus allograft ACLR. They achieved this by assessing their included studies for heterogeneity and then pooling data from common outcome measures between studies. The included studies were not restricted to Level I evidence. The purpose of this study was (1) to conduct a systematic review of meta-analyses comparing autograft and allograft ACLR, (2) to provide an analytic framework for interpreting the currently discordant best available evidence to develop treatment recommendations, and (3) to identify gaps in the literature that require continued investigation. We hypothesized that the use of autogenous tissue confers lower rerupture rates and similar patient outcomes as allograft tissue in patients undergoing ACLR.

## Methods

A systematic review of the literature was performed using the MEDLINE, Cochrane Database of Systematic Reviews, SCOPUS, and EMBASE databases. This search was performed initially on October 1, 2013 and repeated on May 8, 2014. The following search terms were used: anterior cruciate ligament reconstruction, allograft, and autograft, with study type limits set to

**Table 1.** Number of Systematic Reviews or Meta-analyses Actually Cited Compared With the Maximum Number That Could Possibly Have Been Cited

First Author	Date of Publication, mo/yr	Date of Last Literature Search, mo/yr	Number of Systematic Reviews or Meta-analyses Possible to Cite	Number of Systematic Reviews or Meta-analyses Cited
Prodromos <sup>20</sup>	07/2007	NA	0	0
Krych <sup>19</sup>	03/2008	04/2006	0	0
Carey <sup>16</sup>	09/2009	03/2009	2	2
Foster <sup>17</sup>	01/2010	11/2008	2	0
Tibor <sup>21</sup>	01/2010	07/2008	2	2
Hu <sup>18</sup>	02/2013	10/2012	5	5
Kraeutler <sup>6</sup>	10/2013	04/2012	5	3
Yao <sup>22</sup>	05/2014	06/2013	6	2

NA, not available.

meta-analysis or systematic review. The search was limited to English-language articles, and broad search query terms were used to include all possibly applicable studies. All reviewed articles were then manually cross-referenced to ensure that all eligible studies were identified.

The abstracts that resulted from these searches were then reviewed by 2 of us. The inclusion criteria were (1) meta-analyses that compared ACLR with autograft and allograft techniques and (2) English language. The exclusion criteria were (1) meta-analyses that analyzed open ACLR, (2) meta-analyses without clinical outcome data, (3) systematic reviews that did not pool data or perform a meta-analysis, (4) narrative reviews or those without an organized and reported search algorithm, and (5) cadaveric, animal, and other laboratory studies. We then obtained full articles for studies that met both the inclusion and exclusion criteria. The references for each of these citations were then manually screened to ensure that no studies were

missed. The table of contents for the last 2 years of the *Journal of Bone and Joint Surgery*, the *American Journal of Sports Medicine*, *Clinical Orthopaedics and Related Research*, and *Arthroscopy* were manually searched as well for any additional studies. A Preferred Reporting Items for Systematic reviews and Meta-Analyses (PRISMA) flow diagram shows our study selection algorithm (Fig 1).

From the studies that met inclusion criteria, the following data were extracted: primary author, journal of publication, year of publication, conflicts of interest, levels of evidence included, number and publication dates of primary studies included, inclusion and exclusion criteria, performance of heterogeneity analytics, sample size, patient demographics, follow-up period, blinding protocols, range of motion, patient satisfaction, and time to and rate of return to sport. The following standardized outcome scores were extracted: Lysholm, Tegner, International Knee Documentation Society (IKDC), and Cincinnati scores. The incidence of complications was also recorded.

**Table 2.** Author Rationale for Repeating the Systematic Review

First Author	Cited Meta-analyses	Rationale for Repeating Meta-analysis as Abstracted from Article
Prodromos <sup>20</sup>	None	NA
Krych <sup>19</sup>	None	NA
Carey <sup>16</sup>	Prodromos, Krych	"The first systematic review only analyzed instrumented laxity measurements, and the value of that review was further limited by the inclusion of studies with a noncomparative study design (Level of Evidence IV). The second systematic review evaluated only bone–patellar tendon–bone grafts, and the outcomes of interest did not include patient-oriented outcomes or instrumented laxity."
Foster <sup>17</sup>	None	NA
Tibor <sup>21</sup>	Prodromos, Krych	"Two meta-analyses comparing autograft and allograft results have been reported, one with inconclusive results and another that had significant methodological limitations."
Hu <sup>18</sup>	Prodromos, Krych, Carey, Foster, Tibor	"The first meta-analysis ... the findings of this study were compromised by the selection bias and questionable statistical methods. Another meta-analysis ... none of the eligible studies was a prospective comparative study (allograft v autograft). As to the other 3 systematic reviews and meta-analyses, when those studies involving the irradiated allografts were excluded for analysis, their findings were consistent with the results of our study."
Kraeutler <sup>6</sup>	Prodromos, Krych, Foster	"Since 2008, several studies have been published with data on BPTB autografts and/or allografts, which include outcomes on subjective IKDC, Lysholm, Tegner activity, Cincinnati Knee Rating System, KT-1000 arthrometer side-to-side difference, and anterior knee pain, which to our knowledge have not previously been presented in meta-analysis form to compare BPTB autografts and allografts."
Yao <sup>22</sup>	Krych, Kraeutler	"However, new trials have been published since the systematic review reported 5 years ago. Other studies included nonsimple comparative studies that could weaken the reliability of the results."

NA, not available.

**Table 3.** Outcomes Reported by Each of the Included Studies

	Prodromos <sup>20</sup>	Krych <sup>19</sup>	Carey <sup>16</sup>	Foster <sup>17</sup>	Tibor <sup>21</sup>	Hu <sup>18</sup>	Kraeutler <sup>6</sup>	Yao <sup>22</sup>
Clinical indices								
Lysholm	–	–	+	+	–	+	+	+
Tegner	–	–	–	–	–	+	+	+
Cincinnati	–	–	–	–	–	–	+	–
Subjective IKDC	–	–	–	–	–	–	+	+
Knee stability								
IKDC stability	+	+	–	+	+	+	+	–
Instrumented laxity	–	–	+	+	+	+	+	+
Lachman test	–	+	–	–	+	+	–	+
Pivot-shift test	–	+	–	+	+	+	+	+
Hop test	–	+	–	–	–	–	+	+
Subjective outcomes								
Return to activity/sport	–	+	–	–	–	–	+	–
Satisfaction	–	–	–	–	–	–	+	–
Complications								
Overall complications	–	–	–	+	–	–	–	–
Patellofemoral crepitus	–	+	–	–	–	–	–	+
Anterior knee pain	–	–	–	–	–	–	+	+
Graft failure	–	+	+	+	+	+	+	+
Reoperation	–	+	–	–	–	–	–	–

NOTE. “+” indicates that an outcome measure was reported; “–” indicates that an outcome measure was not reported.  
IKDC, International Knee Documentation Committee.

From each meta-analysis we also recorded the following methodological characteristics: the rationale for repeating the meta-analysis, the number of “possible” previous meta-analyses cited relative to the number “actually” cited, the databases used in the literature search, and the conclusions of the meta-analysis regarding whether autografts provided superior clinical outcomes.

The methodological quality of the meta-analyses was scored using the Quality of Reporting of Meta-analyses (QUOROM) system.<sup>13</sup> This system provides a method for evaluating meta-analyses based on the quality of their reporting and methodology in 18 categories. Each meta-analysis was awarded a point in each category if they met more than half of the criteria given in that category for a total of 18 possible points. Meta-analysis quality was also graded using the Oxman-Guyatt quality appraisal tool.<sup>14</sup> The modified Coleman score

was extracted from individual studies when available. In addition, when known biases within the reviewed literature were reported by individual trials, these were recorded.

The Jadad decision algorithm was used to guide interpretation of discordant meta-analyses. Sources of discordance among meta-analyses, as described by Jadad et al.,<sup>15</sup> include differences in the clinical question, inclusion and exclusion criteria, data extraction, quality assessment, data pooling, and statistical analysis. Scoring was performed based on assessment of randomization, randomization methodology, double-blinding, withdrawals or dropouts, and allocation concealment. It was independently applied by 3 of the study authors, whose results were compared to most robustly determine which of the included meta-analyses provided the current best available evidence for treatment recommendations. All statistical

**Table 4.** Search Methodology Used by Each of the Included Studies

First Author	PubMed/MEDLINE	EMBASE	Cochrane				Number of Primary Studies	Primary Studies		Oxman-Guyatt Score
			Library	CINAHL	Scopus	Other		Including Only RCTs	QUOROM Score	
Prodromos <sup>20</sup>	+	–	–	–	–	–	20	–	11	2
Krych <sup>19</sup>	+	+	–	–	+	+	6	–	13	3
Carey <sup>16</sup>	+	+	–	–	–	–	9	–	18	4
Foster <sup>17</sup>	+	–	–	–	–	–	31	–	13	2
Tibor <sup>21</sup>	+	–	+	+	–	+	56	–	16	1
Hu <sup>18</sup>	+	+	+	–	+	–	9	–	16	4
Kraeutler <sup>6</sup>	+	–	–	–	–	–	76	–	13	2
Yao <sup>22</sup>	+	+	+	–	–	–	13	–	17	3

NOTE. “+” indicates that a database was used in the search strategy; “–” indicates a database was not used in the search strategy.

CINAHL, Cumulative Index to Nursing and Allied Health Literature; EMBASE, Excerpta Medica Database; MEDLINE, Medical Literature Analysis and Retrieval System Online; QUOROM, Quality of Reporting of Meta-analyses; RCT, randomized controlled trial.

**Table 5.** Primary Studies Included in Meta-analyses

Primary Study, First Author/Year	Prodromos <sup>20</sup>	Krych <sup>19</sup>	Carey <sup>16</sup>	Foster <sup>17</sup>	Tibor <sup>21</sup>	Hu <sup>18</sup>	Kraeutler <sup>6</sup>	Yao <sup>22</sup>
Prospective comparative studies								
Lawhorn, 2012	—	—	—	—	—	+	—	—
Leal-Blanquet, 2011	—	—	—	—	—	+	+	+
Noh, 2011	—	—	—	—	—	+	+	—
Sun, 2011	—	—	—	—	—	+	+	—
Sun, 2009	—	—	—	—	—	+	+	+
Edgar, 2008	—	—	+	+	—	+	—	—
Gorschewsky, 2005	+	+	+	—	—	—	+	—
Peterson, 2001	+	+	+	+	—	+	+	+
Kleipool, 1998	+	+	+	+	—	+	+	+
Shelton, 1997	—	—	—	—	—	—	—	+
Victor, 1997	—	+	+	+	—	+	—	+
Retrospective comparative studies								
Guo, 2012	—	—	—	—	—	—	—	+
Rihn, 2006	—	—	—	—	—	—	—	+
Barrett, 2005	+	+	+	—	—	—	—	+
Kustos, 2004	—	—	—	—	—	—	—	+
Chang, 2003	+	—	+	—	—	—	+	—
Harner, 1996	+	+	+	—	—	—	—	+
Stringham, 1996	—	—	—	—	—	—	—	+
Saddemi, 1993	—	—	+	—	—	—	—	+
Noncomparative studies								
Prospective	14	0	0	27	56	0	68	0
Retrospective	NR	0	0	27	35	0	NR	0
	NR	0	0	0	21	0	NR	0

NOTE. “+” indicates that a primary study was used in the designated meta-analysis; “—” indicates that the primary study was not used in the designated meta-analysis.

NR, not reported.

analyses were performed using Excel X (Microsoft, Redmond, WA).

## Results

The initial search revealed 267 studies, and after application of our study selection algorithm, 8 studies<sup>6,16-22</sup> fulfilled our inclusion and exclusion criteria and were included (Fig 1). These were published between 2007 and 2014, with all 8 studies performing a meta-analysis. No study reported a conflict of interest, whereas one did not include a conflict of interest statement.<sup>20</sup> The number of primary studies included in each meta-analysis ranged from 6<sup>19</sup> to 76.<sup>6</sup> The number of patients analyzed in these meta-analyses ranged from 534<sup>19</sup> to 5,182,<sup>6</sup> with an average of 1,977 patients per study. Six<sup>6,17-19,21,22</sup> of the 8 studies separately described the sample sizes of patients receiving autografts versus allografts, with 4,760 patients receiving autografts and 1,568 receiving allografts in total. The follow-up period ranged from 24 to 95 months.<sup>18</sup> The mean age ranged from 21<sup>21</sup> to 44.5<sup>19</sup> years for patients receiving autografts and 22<sup>18</sup> to 47.1<sup>19</sup> years for patients treated with allografts.

## Assessment of Previous Meta-analysis Literature

The authors of these studies generally cited most of the previously published meta-analyses (Table 1), with only one study not citing any of them.<sup>17</sup> For 2 of the studies, there were no previous meta-analyses to cite,<sup>19,20</sup>

whereas 3 studies cited all available meta-analyses,<sup>16,18,21</sup> one study cited 3 of the 5 available meta-analyses,<sup>6</sup> and one study cited only 2 of the 6 available meta-analyses.<sup>22</sup> Of the 6 studies in which a literature search was performed after previous meta-analyses had been published, the rationale for repeating the study was provided in 5 instances (Table 2).<sup>6,16,18,21,22</sup> Meta-analyses were most commonly repeated as a result of the limitations of previous studies,<sup>16,18,21</sup> including the inclusion criteria, outcome end points analyzed, and statistical methodology.

## Outcome Measures

There was a significant amount of variability in the clinical outcomes assessed by each meta-analysis (Table 3). Three studies used 2 or more clinical outcome scores,<sup>6,18,22</sup> 2 studies used one clinical outcome score,<sup>16,17</sup> and 3 studies did not use any outcome scores.<sup>19-21</sup> All 8 studies reported on at least one objective measure of knee stability, with 5 studies reporting on 4 such measures.<sup>6,18,19,21,22</sup> Only 2 studies analyzed subjective outcome measures.<sup>6,19</sup> All studies but one assessed for complications.<sup>20</sup> Seven of the 8 studies analyzed graft failure rates,<sup>6,16-19,21,22</sup> whereas only one study analyzed reoperation rates.<sup>19</sup>

## Search Methodology

Although every study queried MEDLINE as part of the literature search, there was significant variability in



**Table 6.** Comparisons Performed by Each Meta-analysis and the Quality Scores for Each Meta-analysis

First Author	Lysholm (SMD)	Lysholm (OR)	Tegner (SMD)	Tegner (OR)	Subjective IKDC (OR)	Cincinnati (OR)	IKDC Stability (MD)	IKDC Stability (OR)	IKDC Stability (RR)	Lachman (OR)	Lachman (RR)	Pivot-shift (OR)
Prodromos <sup>20</sup>	—	—	—	—	—	—	+	—	—	—	—	—
Krych <sup>19</sup>	—	—	—	—	—	—	—	+	—	+	—	+
Carey <sup>16</sup>	+	—	—	—	—	—	—	—	—	—	—	—
Foster <sup>17</sup>	—	—	—	—	—	—	+	—	—	—	—	—
Tibor <sup>21</sup>	—	—	—	—	—	—	—	—	—	—	—	—
Hu <sup>18</sup>	+	—	+	—	—	—	—	—	+	—	+	—
Kraeutler <sup>6</sup>	—	+	—	+	+	+	+	+	—	—	—	+
Yao <sup>22</sup>	+	—	+	—	+	—	—	—	—	+	—	+

NOTE. “+” indicates that a comparison of that outcome measure was performed; “—” indicates that no comparison of that outcome measure was performed.

All 8 studies performed data pooling. IKDC, International Knee Documentation Committee; MD, mean difference; OR, odds ratio; QUOROM, Quality of Reporting of Meta-analyses; ROM, range of motion; RR, relative risk; SMD, standardized mean difference.

the use of other databases, including EMBASE, Scopus, the Cochrane Database of Systematic Reviews, the Cumulative Index to Nursing and Allied Health Literature, and others (Table 4). Two studies used 4 databases,<sup>19,21</sup> and one study used 3 databases,<sup>22</sup> whereas 3 studies used only one database.<sup>6,17,20</sup> No study limited its inclusion criteria to RCTs.

A total of 11 prospective comparative studies and 8 retrospective comparative studies were included among the meta-analyses. Of these 19 comparative studies, one meta-analysis cited 13 studies, 2 meta-analyses cited 9 studies,<sup>16,18</sup> one meta-analysis cited 8 studies,<sup>6</sup> 2 meta-analyses cited 6 studies,<sup>19,20</sup> one meta-analysis cited 4 studies,<sup>17</sup> and one cited none of these (Table 5).<sup>21</sup>

## Study Results

Significant heterogeneity was evident in the overall results of the 8 meta-analyses. Carey et al.<sup>16</sup> found no short-term difference between autograft versus allograft ACLR but cautioned that these results were not age stratified.<sup>16</sup> Foster et al.<sup>17</sup> found that allograft-treated patients had significantly lower mean KT-1000 measurements and were more likely to have normal IKDC scores when compared with autograft-treated patients.<sup>17</sup> In their subgroup analysis, Hu et al.<sup>18</sup> found that patients with bone–patellar tendon–bone (BTB) autografts had better Tegner scores than did patients with BTB allografts. Kraeutler et al.<sup>6</sup> concluded that patients with BTB autografts were more satisfied and had lower graft rupture rates, less knee laxity, and better single-leg hop test results but had more anterior knee pain, lower IKDC scores, and worse pivot shift results. Krych et al.<sup>19</sup> found improved hop test performance and lower rupture rates for BTB autografts compared with allografts. Similarly, Prodromos et al.<sup>20</sup> found higher rupture rates and less stability with allografts than with autografts. Tibor et al.<sup>21</sup> found that knee laxity was greater in allograft-treated than in autograft-treated patients. Lastly, Yao et al.<sup>22</sup> detected

significantly lower rerupture rates in patients receiving autografts.

## Study Quality and Validity

QUOROM scores were assessed for each study and ranged from 11<sup>20</sup> to 18,<sup>16</sup> with 18 being the maximum possible score. The mean was 14.6 with a median of 14.5. Oxman-Guyatt scores varied from one<sup>21</sup> to 4<sup>16,18</sup> (Table 6). The mean score was 2.7 with a median of 2.5. Six studies had Oxman-Guyatt scores of 3 or less,<sup>6,17,19–22</sup> which is generally reflective of “major flaws” in the study methodology.<sup>14</sup>

## Heterogeneity Assessment

Of the 8 meta-analyses, 5 performed a heterogeneity analysis.<sup>16,18,19,21,22</sup> Seven of the 8 studies performed subgroup or sensitivity analyses assessing the influence of parameters such as graft type, graft irradiation, and surgical approach on outcomes (Table 7). Several other parameters were qualitatively reviewed in these studies without performance of formal subgroup or sensitivity analysis. These parameters included sex, time to surgery, graft preservation method, rehabilitation protocol, and rationale for graft choice.

## Discussion

The purpose of this study was to conduct a systematic review of overlapping meta-analyses comparing autograft versus allograft ACLR to elucidate the cause of discordance and to determine which meta-analyses provide the current best available evidence. We hypothesized that ACLR performed with autografts would confer lower rerupture rates and similar patient outcomes as ACLR performed with allografts. The first hypothesis was upheld: multiple studies found a lower rerupture rate with autografts compared with allografts.<sup>6,19,20</sup> However, there did not appear to be significant differences overall in clinical outcomes between the 2 graft types, although some studies did

**Table 6.** Continued

Pivot-shift (RR)	Hop Test (OR)	KT Arthrometry (OR)	KT Arthrometry (RR)	Loss of ROM (OR)	Graft Failure (OR)	Graft Failure (RR)	Reoperation (OR)	Patellofemoral Crepitus (OR)	Anterior Knee Pain (OR)	Return to Activity/Sport (OR)	QUOROM Score	Oxman & Guyatt Score
—	—	—	—	—	—	—	—	—	—	—	11	2
—	+	—	—	—	+	—	+	+	—	+	13	3
—	—	+	—	—	—	+	—	—	—	—	18	4
—	—	—	—	—	—	—	—	—	—	—	13	2
—	—	—	—	—	—	—	—	—	—	—	16	1
+	—	—	+	—	—	+	—	—	—	—	16	4
—	+	—	—	—	+	—	—	—	+	+	13	2
—	+	+	—	+	+	—	—	+	+	—	17	3

show slight benefits to either autografts<sup>18-21</sup> or allografts.<sup>17</sup>

Of the 8 studies included in this review, 2 had Oxman-Guyatt scores of 4 with QUOROM scores of at least 16.<sup>16,18</sup> Because these were the highest scores achieved, these 2 meta-analyses were believed to have provided the highest level of evidence in this review. The first of these was the Level III meta-analysis by Carey et al.,<sup>16</sup> which scored 4 and 18 on the Oxman-Guyatt and QUOROM assessments, respectively. Their study found no significant differences between autografts and allografts in rupture rates or clinical outcomes, although the authors cautioned that their lack of age-group stratification may limit the generalizability of their results. The second of these studies was the Level II meta-analysis by Hu et al.,<sup>18</sup> which scored 4 and 16 on the Oxman-Guyatt and QUOROM assessments, respectively. Their study also concluded that there were no significant differences between autografts and allografts as a whole, although a subgroup analysis indicated that patients with BTB autografts achieved higher Tegner scores than did those with BTB allografts.

None of the meta-analyses found allografts superior to autografts with respect to rerupture rates. Only one study suggested a benefit of allografts over autografts,<sup>17</sup> namely, a small but clinically insignificant decrease in mean laxity and a higher proportion of patients achieving an IKDC grade of A, albeit no difference in the proportion achieving grades of A or B. There were, however, several studies that favored autografts for rupture rates<sup>6,19,20</sup> as well as clinical outcomes.<sup>6,18-21</sup> Two studies<sup>6,19</sup> found superior hop test results in autograft-treated patients. Three studies<sup>6,20,21</sup> found significantly less knee laxity or improved stability, or both, in autograft-reconstructed knees.

This discordance in findings between meta-analyses highlights the fact that further investigation is needed into the effects of age on graft failure. This is especially true in light of findings from 3 previous prospective cohort studies that suggested there exists a higher risk of graft failure when allograft tissue is used in young

active patients.<sup>7,23,24</sup> Additionally, the role of the graft sterilization method in clinical graft failure needs to be better elucidated. Krych et al.<sup>19</sup> found no clinical differences between autograft and allograft ACLR when irradiated or chemically processed allografts were excluded, but whether lower dose irradiation techniques can contribute to clinical failure is still under investigation. Bhatia et al.<sup>25</sup> showed no differences in graft incorporation or structural properties in rabbits that received a nonirradiated allograft in one knee and allograft low-dose (1.2 mrad) in the other. The clinical application of these findings in human patients remains to be seen, but it is clear that the role of both patient age and allograft sterilization techniques in allograft ACL failure needs further examination.

A major strength of this review is the multitude of independent quality-assessment tools used by 3 authors with consensus agreement. Additionally, validated quality-assessment tools<sup>13,14</sup> were used to assess these studies.

### Limitations

Because 8 previously published meta-analyses comparing autograft versus allograft ACLR formed the basis for the present study, it is subject to all of the inherent limitations present in those meta-analyses. These include potential heterogeneity or non-reporting of patients lost to follow-up, or both, time from injury to surgery, rehabilitation protocol, and fixation methods. The meta-analyses also did not adequately appraise the preoperative functional status of the patients. The surgical technique, allograft sterilization process, and other graft characteristics were inconsistently described and could have significantly influenced the findings of the analyses. Finally, the Jadad decision algorithm for meta-analysis interpretation could not be applied to the meta-analyses in this review because none of them limited their inclusion criteria to RCTs. Further research should compare autografts versus allografts in ACL reconstruction according to the graft source, age group, and allograft sterilization techniques.

**Table 7.** Heterogeneity or Subgroup Analyses of Primary Studies

	Prodromos <sup>20</sup>	Krych <sup>19</sup>	Carey <sup>16</sup>	Foster <sup>17</sup>	Tibor <sup>21</sup>	Hu <sup>18</sup>	Kraeutler <sup>6</sup>	Yao <sup>22</sup>
Statistical heterogeneity analysis	—	+	+	—	+	+	—	+
Subgroup or sensitivity analysis								
Primary study quality	—	+	+	—	—	+	—	+
Age	—	0	—	—	0	0	+	0
Sex	—	—	—	—	0	—	—	—
Time to surgery	—	—	—	—	0	—	—	0
Follow-up interval	—	0	0	—	—	0	+	0
Follow-up rate	—	—	—	—	—	—	—	—
Rehabilitation protocol	—	0	—	—	—	0	—	—
Graft type	—	—	0	—	+	0	—	0
Graft preservation method	0	—	0	—	—	0	0	+
Rationale for graft choice	—	0	—	—	—	—	—	—
Surgical approach	—	0	—	—	—	0	0	—
Lysholm (graft type)	—	—	—	—	—	+	—	—
Tegner (graft type)	—	—	—	—	—	+	—	—
Graft failure (graft type)	—	—	—	—	—	+	—	—
IKDC stability (graft type)	+	—	—	—	—	—	—	—
IKDC stability (graft irradiation)	+	—	—	—	—	—	—	—
Subjective IKDC (graft type)	—	—	—	—	—	+	—	—
Instrumented laxity (graft type)	—	—	—	+	—	+	—	—
Lachman (graft type)	—	—	—	—	—	+	—	—
Pivot-shift (graft type)	—	—	—	—	—	+	—	—
Pivot-shift (surgical approach)	—	—	—	—	—	—	+	—

NOTE. “+” indicates that formal sensitivity or subgroup analysis was performed; “—” indicates that formal sensitivity or subgroup analysis was not performed; and “0” indicates that descriptive data were provided or discussed, but no analysis was performed.

IKDC, International Knee Documentation Committee.

## Conclusions

According to this systematic review of overlapping meta-analyses comparing autografts and allografts for ACLR, the current best available evidence suggests no differences in rerupture rates and clinical outcomes. Lower quality meta-analyses indicate that autografts may provide a lower rerupture rate with better hop test performance and objective knee stability than do allografts.

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