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Meniscus Status at ACL Reconstruction is Associated with the Presence of Radiographic Signs of Osteoarthritis at 5–10 Year Follow-up: A Systematic Review

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Abstract

Background—The development of premature osteoarthritis after ACL reconstruction is significant cause of morbidity in young, active individuals. Meniscal injuries are frequently noted at the time of reconstruction and the critical role of an intact meniscus in the prevention of osteoarthritis has been well documented. The purpose of this review is to evaluate the impact of meniscal status at the time of ACL reconstruction on the subsequent development of osteoarthritis as determined radiographically.

Methods—A systematic review of the literature was performed to identify studies publishing outcomes of ACL reconstructions with at least two years follow-up that included radiographs. These studies were narrowed, focusing on those which compared radiographic outcomes of at least two groups of patients based of meniscus status at the time of ACL reconstruction.

Results—Eleven studies met our inclusion and exclusion criteria. Patients who underwent partial meniscectomy at the time of ACL reconstruction were significantly more likely to develop radiographic evidence of osteoarthritis than those with normal menisci at 5–10 year follow-up. Comparison of patients who underwent meniscal repair with other groups revealed inconsistent findings. Virtually all patients who underwent complete meniscectomy at the time of ACL reconstruction exhibited radiographic evidence of osteoarthritis at follow-up.

Conclusions—The presence of meniscal injury requiring partial meniscectomy at the time of ACL reconstruction significantly increases osteoarthritis risk.

Level of Evidence—2 - Systematic review of retrospective prognostic studies and lesser quality prospective prognostic studies with consistent results

INTRODUCTION

ACL reconstruction utilizing modern techniques allows clinically stable ligament reconstruction while minimizing scarring and potential trauma to the knee joint.[13, 40] Aggressive modern rehabilitation techniques reliably restore knee range of motion and quadriceps strength necessary for normal knee function.[29, 46, 47] However, the development of premature arthritis following ACL reconstruction persists and continues to be the focus of significant basic science and clinical research.[3, 16, 25, 39, 47]

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The critical biomechanical role of the meniscus in the knee has long been known and the development of osteoarthritis has been associated with meniscectomy.[6, 23] Several authors have documented the influence meniscal injuries can have on outcome after ACL reconstruction.[4, 27, 31, 32, 47, 50] The purpose of this manuscript is to perform a systematic review to address the following clinical question: What is the impact of meniscal status at the time of ACL reconstruction on the subsequent development of radiographic signs of osteoarthritis?

MATERIALS AND METHODS

Inclusions and Exclusion Criteria

Inclusion and exclusion criteria for this review are summarized in Table 1. Papers were included if they included descriptions of meniscal status at the time of primary ACL reconstruction with hamstring or patellar tendon autograft using arthroscopic or arthroscopic-assisted techniques. Follow-up was required to be at least two years consisting of radiographic quantification of the development of osteoarthritis broken down by meniscal status. Studies were excluded if they included skeletally immature patients, revision ACL reconstruction, allograft, concurrent non-meniscal procedures, reconstruction with grafts other than patellar tendon or hamstring, open procedures, or multi-ligament knee injuries.

Literature Review

The literature search is summarized in Figure 1. A MEDLINE literature search was preformed to identify all English language publications from January 1, 1966 through January 1, 2007 addressing the influence of meniscal status on the development of osteoarthritis in humans undergoing ACL reconstruction. A search for articles containing the term “reconstruct*” as well as either “anterior cruciate” or “ACL” yielded 2805 results.[#] These results were further focused by requiring that the citation also contain one of the follow terms: “menisc*,” “radiolog*,” “radiograph*, “osteoarthritis,” or “arthritis,” resulting in 957 publications. The title and abstract of these publications were reviewed and studies not related to ACL reconstruction were excluded. Additionally, studies in which the title and abstract indicated a reason for exclusion using the above criteria were excluded. Full text of the remaining 241 publications was obtained. These articles were reviewed and excluded for absence of radiographs (70 studies), inclusion of patients with multiple ligament injuries (9 studies), use of reconstruction methods other than arthroscopic or arthroscopic-assisted patellar tendon or hamstring tendon reconstruction (19 studies), follow-up of less than 2 years (32 studies), or absence of radiographic findings broken down by meniscal status at the time of repair (99 studies). Twelve studies met the inclusion and exclusion criteria.[2, 4, 14, 17, 20, 40, 42–44, 47, 49, 50] Two of these studies[43, 44] were excluded because they represented a subset of data from a larger study that was included in the analysis.[47]

A search of the Embase database was then performed utilizing the same search strategy. The title and abstracts of the resulting 950 studies were reviewed and excluded if they were previously identified in the MEDLINE search, were unrelated to ACL reconstruction, or met one of the above exclusion criteria. Full text of the remaining 16 articles was obtained. All were then excluded from the study based on lack of radiographs (8 studies), use of reconstruction methods other than arthroscopic or arthroscopic-assisted patellar tendon or hamstring tendon reconstruction (1 study), follow-up of less than 2 years (1 study), or absence of radiographic findings broken down by meniscal status at the time of repair (6 studies).

[#]The use of the asterisk (*) symbol in a MEDLINE search denotes truncation of a word. All possible endings of the root word are searched.

Searches of the Cochrane Central Register of Controlled Trials and the Cumulative Index to Nursing and Allied Health Literature (CINAHL) utilizing the same search criteria yielded 56 and 201 studies respectively. The search identified several studies already included in this review but no new studies meeting criteria were identified. Exhaustive review of the references of all full text articles was performed to identify additional papers meeting inclusion and exclusion criteria for this study. One additional study not previously identified was obtained and included in the study.[37] Data was extracted from these eleven papers by two authors independently to ensure accuracy. Discrepancies were resolved by discussion until a consensus was reached.

Statistics

Data were analyzed by calculating the risk of developing radiographic signs of osteoarthritis for each treatment group in the included studies. A Fisher's exact test was used to compare the frequency of these changes between patient groups. Risk difference was calculated by subtracting the risk of developing changes in one group from the risk of developing these changes in another. Risk ratios were calculated by dividing the risk of developing changes in one group by the risk of developing these changes in another. Confidence intervals were calculated for both risk differences and risk ratios. All statistical calculations were performed using Stata (Statacorp, College Station, TX).

RESULTS

Demographics

Demographics of each study are shown in Table 2. The majority of the publications are retrospective prognostic studies (Level 2 evidence) designed after treatment was provided to evaluate the impact of meniscus status on the later development of osteoarthritis. The exception is the 2002 study by Wu *et al,* which was prospectively designed specifically to address this question. However, follow-up of less than 80 % qualifies the Wu study as level 2 evidence. Mean patient age at the time of reconstruction is generally consistent in the studies and ranges from 23–31 years. All studies include a majority of males. Most of the studies include of majority of patients with chronic ACL tears defined by either the time interval from injury to surgery or by the occurrence of episodes of giving way prior to reconstruction. The study by Hart *et al* included only patients within 6 months of injury. Articular cartilage status at the time of ACL reconstruction is described in eight of the eleven studies. Five studies exclude patients with articular cartilage injury defined as Outerbridge score greater than 2.[4, 14, 17, 37, 40]

Surgical Technique

Only studies including ACL reconstructions using mini-open, arthroscopic-assisted, or endoscopic techniques were examined in this study. In all cases but one, the authors used the same technique for all reconstructions included in the study. Wu *et al* utilized the arthroscopic-assisted technique early in their study then changed to an all endoscopic technique. The studies all excluded patients that underwent concurrent surgical procedures other than chondroplasty and meniscal procedures.

Rehabilitation

Rehabilitation protocols are reported in 7 of 11 studies and are detailed in Table 3. Partial weight-bearing was generally allowed within the first 24 hours with Johma *et al* and Aglietti *et al* delaying until 3–4 weeks. Full weight-bearing was generally allowed at 4–8 weeks although Wu *et al* allowed full weight-bearing at 24 hours. Most authors required the use of

a hinged knee brace until full weight-bearing. Giron *et al* did not employ bracing and Wang *et al* only braced patients who underwent meniscal repair.

Follow-up and Radiographic Evaluation

Mean follow up ranged from 4.5 to 13 years with an average of 8.3 years for all studies. Follow-up radiographs were generally obtained in greater than 60 % of patients from the initial cohorts, although the Patel (55 %) and Shelbourne (39 %) papers had much lower follow-up rates. All studies utilized standing AP or PA views when assessing joints for osteoarthritis. Some authors supplemented this view with lateral,[2, 4, 14, 17, 24, 40, 42, 47, 50] notch,[14] 30 or 45 degree flexion,[3, 24, 40, 47] or Merchant views.[2, 4, 14, 17, 24, 40, 47, 49]

The International Knee Documentation Committee (IKDC) rating system was most frequently used to assess joint degeneration radiographically.[19] The Kellgren and Lawrence,[28] Fairbank,[11] and Hospital for Special Surgery[48] rating scales were also utilized. The papers generally defined radiographic evidence of osteoarthritis as an IKDC score of B or worse, Kellgren and Lawrence score of 2 or worse, Ahlback score of I or worse, the presence of Fairbanks changes, or HSS score less than 26. Definitions utilized in each study are shown in Table 3. Joint space loss is a key metric in each of the classification systems. Rough correlation between the joint space losses using each classification systems is shown in Table 4. Because the numeric HSS system is based on joint space narrowing, cyst formation, sclerosis, and coronal plane angulation, a specific score cannot be given based on joint space loss alone.

Meniscus Status and Correlation with Radiographic Evidence of Osteoarthritis

Table 5 describes the articular cartilage status of the patients in each study by Outerbridge grade and correlates meniscal status with radiographic findings. Three studies compare radiographic evidence of osteoarthritis in patients with normal menisci to those with repaired menisci.[2, 4, 20] The study by Hertel *et al* demonstrates a significant difference between the two groups while the two studies by Aglietti *et al* find no significant difference.

Two papers contain a comparison of results of patients who underwent total meniscectomy versus normal or repaired meniscus.[40, 50] Both studies found a statistically significant increase in the percentage of patients with radiographic evidence of osteoarthritis in the total meniscectomy groups.

Two authors did not report radiographic data for patients who underwent total meniscectomy separately from those who underwent partial meniscectomy. Both papers did show significantly increased radiographic evidence of osteoarthritis in patients who underwent meniscectomy when compared with patients with normal[42] or normal and/or repaired menisci.[47]

Six studies include comparison of radiographs of patients with normal menisci versus those who underwent partial meniscectomy.[2, 4, 14, 17, 20, 37] These findings are outlined in Table 6. Three of the six studies found significantly more radiographic changes in the partial meniscectomy group, while the other three studies showed a trend toward more radiographic evidence of osteoarthritis in the partial meniscectomy group that did not reach statistical significance. The relative risk of developing radiographic changes with a partial meniscetomy (Figure 2) and the risk reduction associated with a normal meniscus (Figure 3) are presented along with 95 % confidence intervals.

Comparison of patients with normal or repaired menisci showed higher rates of radiographic degeneration than the partial meniscectomy group in one paper.[49] Repaired menisci were compared with partial meniscectomy in three studies. Significantly more degenerative

change in the partial meniscectomy group was noted in two studies[2, 4] while one author noted no difference.[20]

Analysis of Heterogeneity

An anaylsis of heterogeneity was performed on the six studies noted above to compare radiographic signs of osteoarthritis in patients with normal menisci with those that underwent partial meniscectomy.[2, 4, 14, 17, 20, 37] Qualitatively, the studies used different outcome measures of radiographic systems to grade degenerative joint disease including HSS score, Faribank grade, IKDC grade, and Ahlback grade. Even studies which used the same system defined different cutoffs between cases of radiographic DJD and non-cases, with one study defining changes as an IKDC grade worse than A while others defined changes as an IKDC grade worse than B. Quantitatively, we evaluated the null hypothesis that the findings of the individual trials are the same. In the most extreme example, comparing number of cases of radiographic changes in the partial meniscectomy groups of the Patel[37] and Aglietti[2] studies [100% (13 out of 13) versus 35% (7 out of 20), respectively] yields a risk difference of 65% with a P value of 0.0002 (2-sided Fisher's Exact test). Since $p < 0.10$, we assume heterogeneity exists between the studies and thus elected not to combine the data in a meta-analysis.

DISCUSSION

The findings in this systematic review correlate the status of the meniscus at the time of ACL repair with the frequency of the development of radiographic evidence of osteoarthritis. They consistently demonstrate that an intact meniscus and to a lesser extend a repaired meniscus at the time of ACL reconstruction is correlated with a decreased likelihood of developing radiographic evidence of osteoarthritis in the first 5–10 years after reconstruction.

Abundant research on stable knees has shown the consequences of complete meniscectomy in the premature development of osteoarthritis.[5, 11, 22, 23, 33] Partial meniscectomy is generally better tolerated, with good clinical outcomes and radiographic degeneration comparable with controls noted at up to 15 years.[8, 10, 21, 45] One randomized study did find increased clinical symptoms patients who underwent complete meniscectomy compared with those who underwent partial meniscectomy but radiographic differences were not found.[18] The role of the menisci as a secondary stabilizers in the ACL-deficient knee have long been known and clinical results have been poor after complete meniscectomy in these patients.[7, 30] The finding in this review of frequent development of radiographic signs of osteoarthritis after ACL reconstruction in patients with complete meniscectomy is consistent with previous findings in both stable and unstable knees and is expected.

Three studies in this review analyze a group of patients who underwent meniscal repair.[2, 4, 20] The two studies by Aglietti *et al* are consistent in their finding that the meniscal repair group and normal meniscus group exhibit similar radiographic findings and are both superior to the partial meniscectomy group. These data are in contrast to the findings by Hertel *et al* in which the meniscus repair group behaved more similarly to the partial meniscectomy group. These discrepancies may reflect the success of the meniscal repairs in the studies and possibly different repair methods. Aglietti *et al* use the outside-in method of Morgan and Casscells while Hertel *et al* do not describe their method of repair.[34] The findings of Aglietti *et al* are not surprising given previous documentation of the success of concurrent ACL and meniscal repair exceeding that of isolated meniscal repair.[9, 35, 38]

This review also describes those patients with a partial meniscectomy as greater than five times more likely to develop radiographic evidence of osteoarthritis than patients with an

intact meniscus at ACL reconstruction. This finding stresses the key role of the meniscus in prevention of radiographic signs of osteoarthritis. The relatively low rate of radiographic changes (10 %) in the group with intact menisci is much lower than documented rates of osteoarthritis in patients with conservatively treated ACL tears (40 %) without meniscal injury at similar follow-up interval.[41] This finding supports the position that ACL reconstruction in a knee with intact menisci does not increase risk of osteoarthritis.

We chose to focus this review on patients reconstructed arthroscopically or with mini-open techniques utilizing hamstring or patellar autografts. These techniques represent the most common ACL reconstruction methods in use today and the rates of osteoarthritis development described above are applicable to most patients with isolated ACL tears treated with these methods. Authors using open reconstruction techniques have been reported similar findings, with partial or complete meniscectomy at the time of reconstruction predicting greater risk of development of osteoarthritis in 4–7 year follow-up.[1, 12, 26, 31]

The data presented above highlight the correlation of meniscus status at the time of ACL repair with development of radiographic evidence of osteoarthritis in patients with isolated ACL injuries. Several authors reporting 3–5 year follow-up ACL reconstruction cohorts that include patient with concomitant collateral ligament injury have also noted the correlation of meniscectomy at the time of repair with subsequent development of radiographic evidence of osteoarthritis.[15, 24, 32, 36]

This review provides strong evidence of the correlation between meniscus status at ACL reconstruction and the subsequent development of radiographic evidence of osteoarthritis. The major weakness of the study; however, is its inability to demonstrate causality. The correlation between meniscus status and radiographic changes does not necessarily indicate that the meniscus status is related to the development of these changes. It is possible that in those patients with a concomitant meniscal injury we are dealing with higher energy injuries or more chronic ACL injuries. More damage to the articular cartilage at the time of injury or recurrent episodes of instability in chronic cases could lead to the development of later osteoarthritis regardless of meniscal status. Similarly, because the medial meniscus is a secondary restraint of anterior tibial subluxation in the absence of an ACL, patients with meniscal pathology likely experience greater instability and hence greater cartilaginous injury prior to reconstruction. Finally, meniscal pathology may be associated with other patient characteristics not identified in this review that could explain an increased incidence of radiographic signs of osteoarthritis in this patient population.

Assessment of the impact of medial versus lateral meniscal pathology on outcome after reconstruction was not possible as the majority of studies did not distinguish between them when reporting radiographic findings.

The conclusions of this review are subject to the limitations and possible biases of the source studies. Selection bias was minimal as all studies enrolled a consecutive series of patients with well-defined selection criteria, although differences in patient selection criteria between studies such as the inclusion or exclusion of patient with articular cartilage lesions and the chronicity of injury do result in a somewhat heterogeneous overall patient population. Care must thus be taken when comparing results from study to study. Similarly, performance bias was also minimized as all studies utilized that same reconstruction technique and same surgeon for all patients, regardless of meniscal pathology. Transfer bias is a concern in this review as several of the studies had rather poor follow-up. It is possible that patients with post-operative symptoms are more likely to follow-up than those who are without symptoms. It is unclear what impact, if any, this bias may have as both patients with and without meniscal pathology would be affected. Detection bias appears minimal as both

groups were evaluated using the same radiographic techniques within each study. It should be noted; however, that the outcome measure utilized in each study, radiographic evidence of osteoarthritis, does not necessarily indicate the presence of osteoarthritis as it is a clinical diagnosis.

The ideal method for establishing causality in the link between meniscal pathology and osteoarthritis would be the utilization of a prospective study design. Patients should be carefully selected, excluding those patients with internal derangement of the knee other than ACL and meniscal pathology. Careful examination of all patient and injury characteristics must be undertaken to identify any possible confounding variables. Finally, an attempt should be made to determine the degree of injury suffered by the articular cartilage at the time of injury – possibly through MRI evaluation of the extent of the bone bruise present. Outcome measures should include radiographic assessment as well as a validated patient-oriented clinical outcome measure such as the Knee Injury and Osteoarthritis Outcome Score (KOOS) or the Western Ontario and MacMaster University Osteoarthritis Index (WOMAC).

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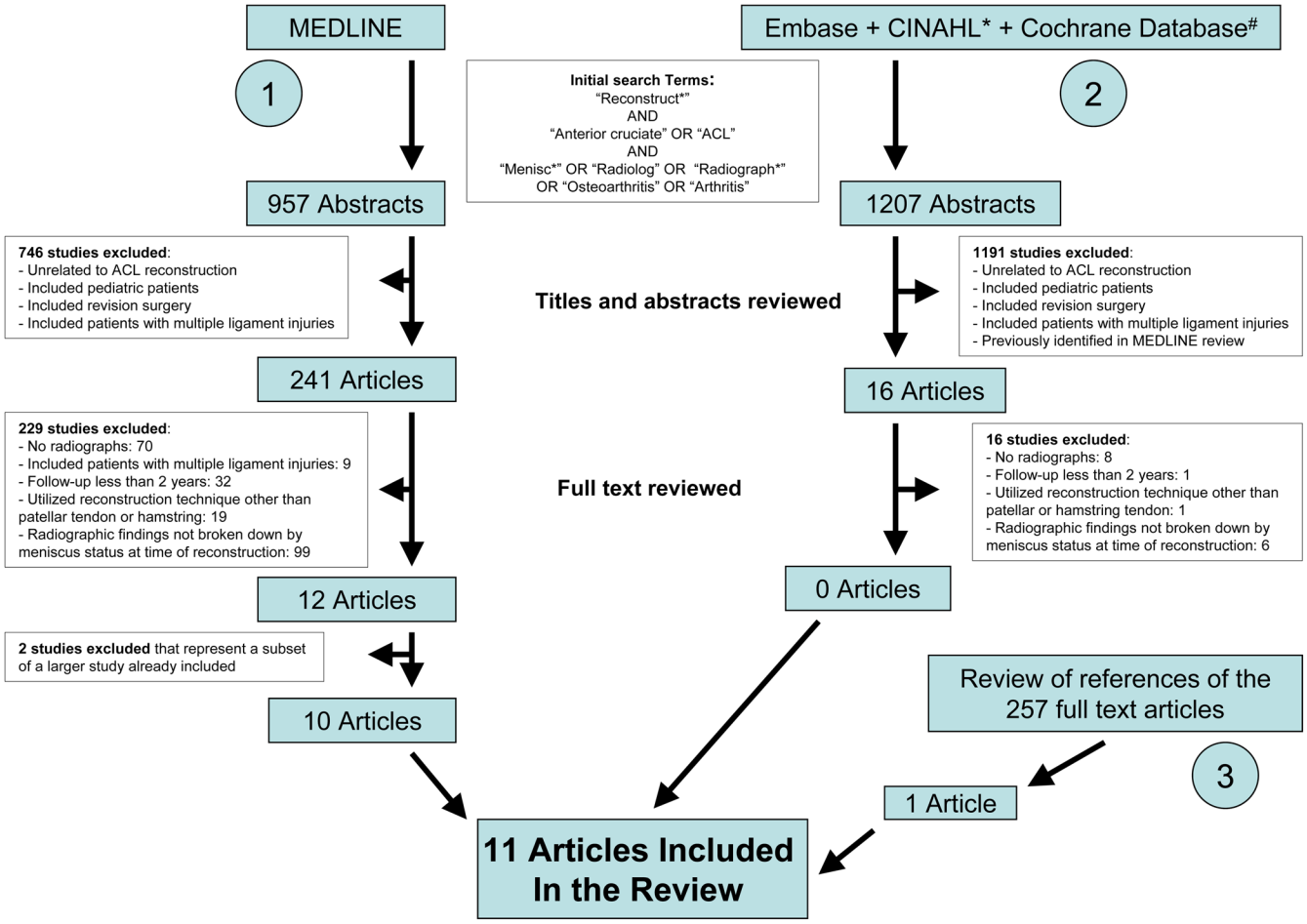

Figure 1.

The search strategy of the systemic review is shown, including MEDLINE, Embase, CINAHL, and the Cochrane Central Registry of Controlled Trials, as well as a search of the references of all full-text articles. Eleven studies were identified for nclusion.

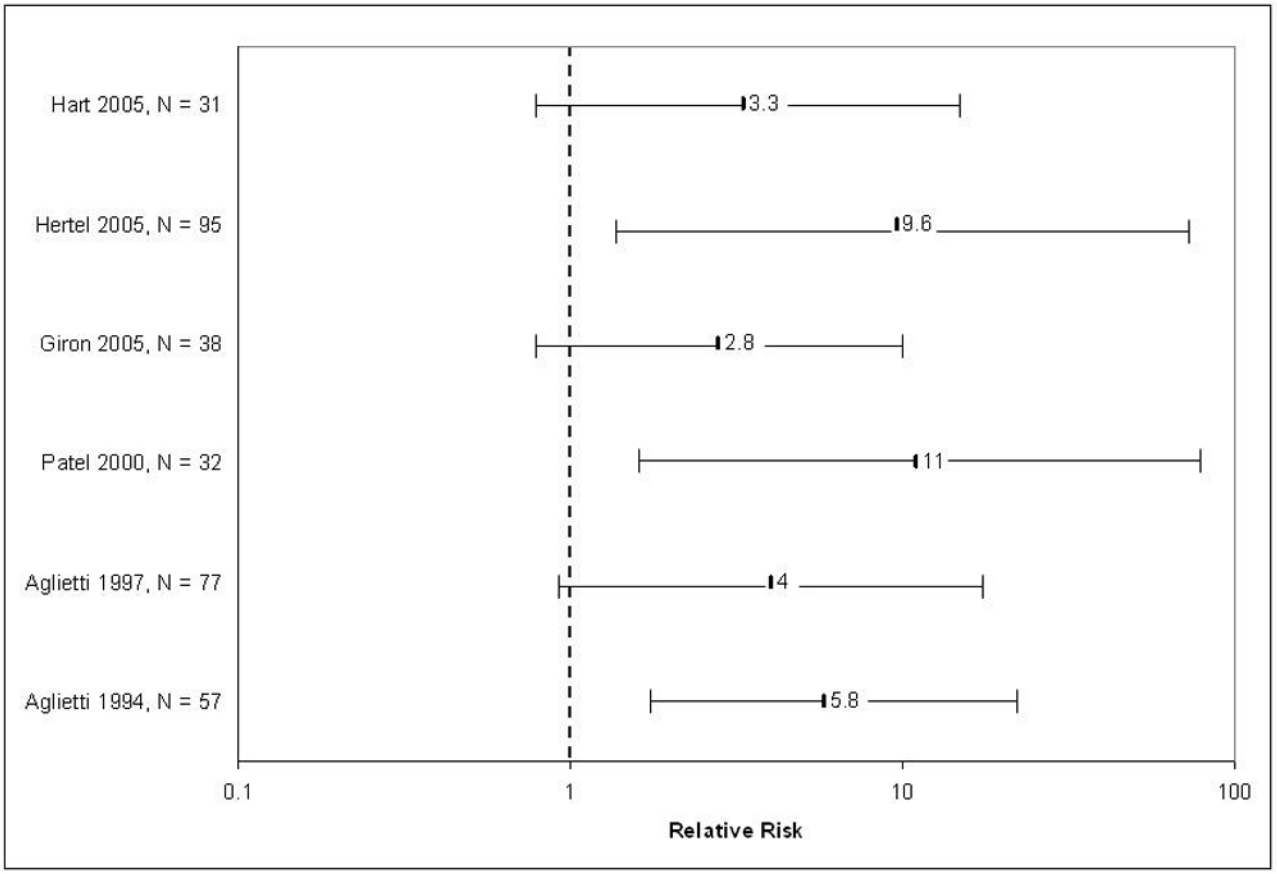

Figure 2.
The relative risk of development of radiographic signs of osteoarthritis in patients with partial meniscectomy was calculated by dividing the percentage of patients with a partial meniscectomy at the time of ACL reconstruction who developed signs of osteoarthritis by the percentage of patients with a normal meniscus who developed signs of osteoarthritis.

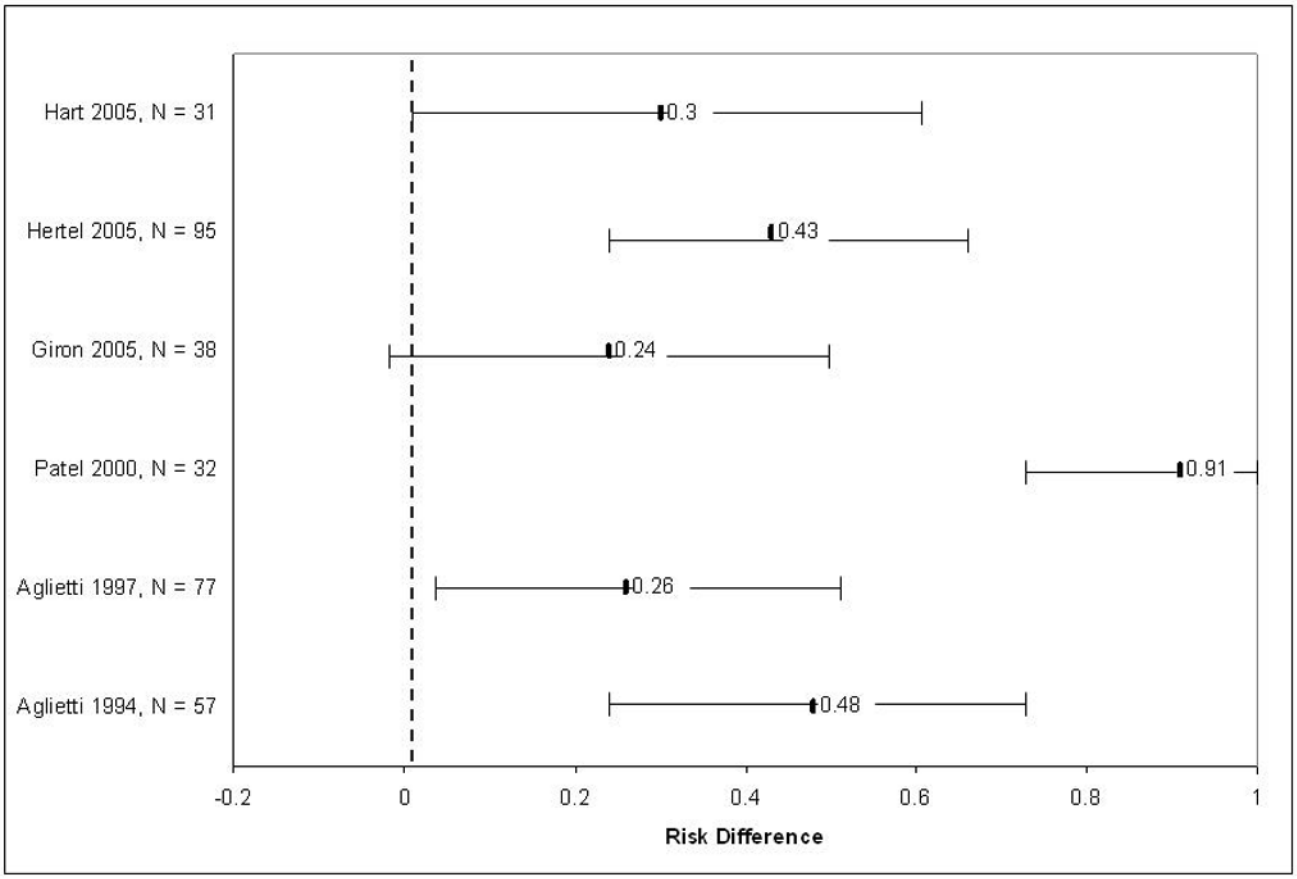

Figure 3.

The absolute risk reduction of the development of osteoarthritis associated with a normal meniscus was calculated by subtracting the percentage of patients with a normal meniscus at the time of ACL reconstruction who developed signs of osteoarthritis from the percentage of patients with a partial meniscectomy who developed signs of osteoarthritis.

Table 1

Inclusion and Exclusion Criteria

Inclusion Criteria	Exclusion Criteria
Primary ACL reconstruction	Revision ACL reconstruction
Contains description of meniscal status at the time of ACL reconstruction with at least two meniscal groups	Skeletally immature patients
Follow-up of at least 2 years	Performance of concurrent non-meniscal procedures
Radiographic evaluation of development of osteoarthritis at follow-up	Use of artificial ligaments or ligament augmentation devices
Breakdown of development of radiographic findings by meniscal status	Multi-ligament knee injuries
Arthroscopic, arthroscopic-assisted, or mini-open ligament reconstruction	Open procedures
Reconstruction using patellar tendon or hamstring autograft	Primary ligament repair or reconstruction with graft other than patellar tendon or hamstring
	Reconstruction using allograft

Table 2

Patient Demographics

Author	Journal	Year	Level	Patient Age Mean (range)	Percent male	Acute v Chronic	Method of Reconstruction	Initial Cohort	Final Clinical Cohort	Final Radiograph Cohort	Articular Cartilage Status Given
Salmon	AJSM	2006	2	27	70 %	47 % > 3 mos	Arthroscopic BTB	67	49 (73 %)	43 (64 %)	Yes
Seon	International Orthopedics	2006	2	30 (18–58)	95 %	72 % > 6 mos	Arthroscopic BTB	70*	58 (83 %)	58 (83 %)	No
Hart	JBJS-Br	2005	2	28 (18–47)	68 %	0 % > 6 mos	Arthroscopic BTB	50†	31 (62 %)	31 (62 %)	Yes
Hertel	KSSTA	2005	2	31	59 %	48 % > 4 wks	Mini-arthrotomy BTB	155‡	95 (61 %)	95 (61 %)	No
Giron	KSSTA	2005	2	29 (17–53)	79 %	100 % > 30 days	Arthroscopic Hamstrings	46	43 (93 %)	38 (83 %)	Yes
Wang	Chang Gung Medical Journal	2004	2	31 (19–57)	73 %	100 % > 3 mos	Arthroscopic BTB	51§	43 (84 %)	43 (84 %)	No
Wu	AJSM	2002	2	24 (15–45)	57 %	73 % > 4 mos	2 Incision Arthroscopic Assisted/Arthroscopic BTB	103	63 (61 %)	63 (61 %)	Yes
Patel	Arthroscopy	2000	2	33 (18–53)	75 %	72 % > 6 mos	Arthroscopic BTB	44	32 (73 %)	32 (73 %)	Yes
Shelbourne	AJSM	2000	2	23 (12–53)	73 %	59 % Had eipsode of give-way	Mini-arthrotomy BTB	1231	921 (75%)	482 (39%)	Yes
Aglietti	KSSTA	1997	2	23 (15–40)	81 %	100 % > 3 mos	2 Incision Arthroscopic Assisted BTB	117‖	89 (76 %)	77 (66 %)	No
Aglietti	CORR	1994	1	NR¶	NR	100 % > 3 mos	2 Incision Arthroscopic Assisted BTB	57	57 (100 %)	57 (100 %)	Yes

AJSM – American Journal of Sports Medicine

JBJS-Br – Journal of Bone and Joint Surgery – British Edition

KSSTA – Knee Surgery, Sports, Traumatology, and Arthroscopy

CORR – Clinical Orthopaedics and Related Research

* Initial cohort was 80 patients – 10 patients with multiple ligament injuries were excluded

† Initial cohort was 60 patients – 10 patients with articular cartilage damage were excluded

‡ Initial cohort was 159 patients – 4 patients with PCL injury or fracture were excluded

[§]Initial cohort was 52 patients – 1 patient who underwent osteochondral allograft treatment was excluded

[¶]Initial cohort was 146 patients – 29 patients with multiple injuries and those treated with older techniques were excluded

Table 3

Rehabilitation Protocol and Follow-up

Author	Year	Time to Partial Weight-bearing	Time to Full Weight-bearing	Brace use	Years to follow-up Mean (Range)	Radiographs Obtained	Radiographic Classification System Utilized
Salmon	2006	24 Hours	4 weeks	30–90 for 4 weeks	13	Stand AP Stand 30 PA Lateral Merchant	IKDC System Grade B,C or D
Seon	2006	24 Hours	8 weeks	30–90 for 8 weeks	11.2 (8.6–14)	Stand AP Lateral	Kellgren and Lawrence Grade ≥ 2
Hart	2005	NR	NR	NR	10 (9–13)	Stand AP Lateral Merchant	Ahlback Grade ≥1
Hertel	2005	NR	NR	NR	10.7 (9.2–12)	Stand AP	IKDC System Grade B,C, or D
Giron	2005	Immediate	3–5 weeks	None	5	Stand AP Lateral Merchant Notch	IKDC System Grade B,C, or D
Wang	2004	Immediate	4–6 weeks if meniscus repaired Immediatein others	0–90 for 4–6 weeks if meniscus repaired None in others	5.8 (3.8–7.2)	Stand AP Merchant	Ahlback Grade ≥1
Wu	2002	24 Hours	24 Hours	0–90 for 4 weeks if meniscus repaired Hinged brace with full ROM for 4 weeks in others	10.5 (9–13)	Stand PA Lateral	Fairbank Grade ≥1
Patel	2000	NR	NR	NR	5.9 (5–8.5)	NR	Fairbank Grade ≥1
Shelbourne	2000	NR	NR	NR	7.6 (5–15)	Stand 45 PA Lateral Merchant	IKDC System Grade B,C, or D
Aglietti	1997	3 weeks	8 weeks	10–90 for 4–6 weeks	7 (5.2–8.7)	Stand AP Lateral Merchant	IKDC System Grade C or D
Aglietti	1994	NR	NR	NR	4.5 (3–7.5)	Stand AP Stand 45 PA Lateral Merchant	HSS Evaluation Score < 26

AP – Antero-posterior

PA – Postero-anterior

NR – Not Reported

Table 4

Correlation of Joint Space Narrowing Across Radiographic Staging Systems

Joint Space	International Knee Documentation Committee (IKDC)	Kellgren and Lawrence	Ahlback	Fairbank Changes
Normal	A	1*		Absent
Minimal Narrowing	B†	2‡		Absent
Moderate Narrowing	C§	3/	1¶	Present
Severe Narrowing	D#	4**	II – V††	Present

*Defined as doubtful narrowing

†Defined as joint space greater than 4 mm

‡Defined as possible narrowing

§Defined as joint space 2 – 4 mm

/Defined as definite joint space narrowing

¶Defined as joint space < 3 mm

#Defined as joint space < 2 mm

**Defined as marked joint space narrowing

††Defined as complete loss of joint space

Table 5

Radiographic Signs of Osteoarthritis by Meniscus Status at Reconstruction Documented Meniscal Status at the Time of ACL Reconstruction

Author	Year	Articular Cartilage Outerbridge Grade at Reconstruction	Normal Menisci	Normal or Repaired Menisci	Repaired Menisci	Partial Meniscectomy	Partial or total Meniscectomy	Total Meniscectomy	Significance
Salmon	2006	0–2		50 %				87 %	p = 0.006
Seon	2005	NR	20 % (5/25)				60 % (20/33)		p = 0.003
Hart	2005	0–2	13 % (2/15)			44 % (7/16)			p = 0.11
Hertel	2005	NR	5 % (1/20)		43 % (6/14)	48 % (14/29)			normal v repaired – p = 0.01 normal v partial -p = 0.01 repaired v partial – p = 0.5
Giron	2005	0–2	18 % (3/22)			31 % (6/16)			p = 0.08
Wang	2004	NR		38 % (6/16)		74 % (20/27)			p = 0.03
Wu	2002	0–4		8 % (2/25)				100 % (9/9)	p = 0.000001
Patel	2000	0–2	9 % (1/11)			100 % (13/13)			p = 0.00001
Shelbourne	2000	0–4		12 % (28/235)			38 % (78/247)		p = 0.003
Aglietti	1997	0–4	9 % (2/23)		7 % (1/15)	35 % (7/20)			normal v repair – p = 1.0 normal v partial -p = 0.06 repair v partial - p = 0.1
Aglietti	1994	0–2	10 % (2/20)		28 % (5/18)	58 % (11/19)			normal v repair – p = 0.2 normal v partial -p = 0.002 repair v partial - p = 0.1

NR – Not Reported

Table 6

Comparison of Radiographic Signs of Degeneration in Patients with Normal Menisci and those with Partial Meniscectomy Meniscus Status at ACL Reconstruction

Author	Year	Years to follow-up Mean (Range)	Percent Follow-up	Normal menisci	Partial meniscectomy	Significance	Radiographic Classification System Utilized
Hart	2005	10 (9–13)	62 %	13 % (2/15)	44 % (7/16)	p = 0.11	Ahlback Grade ≥ 1
Hertel	2005	10.7 (9.2–12)	61 %	5 % (1/20)	48 % (14/29)	p = 0.001	IKDC System Grade B,C, or D
Giron	2005	5	83 %	18 % (3/22)	31 % (6/16)	p = 0.09	IKDC System Grade B,C, or D
Patel	2000	5.9 (5–8.5)	73 %	9 % (1/11)	100 % (13/13)	p = 0.00001	Fairbank Grade ≥ 1
Aglietti	1997	7 (5.2–8.7)	66 %	9 % (2/23)	35 % (7/20)	p = 0.06	IKDC System Grade C or D
Aglietti	1994	4.5 (3–7.5)	100 %	10 % (2/20)	58 % (11/19)	p = 0.02	HSS Evaluation Score < 26