Prevalence of Chondral Defects in Athletes' Knees: A Systematic Review

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ABSTRACT

FLANIGAN, D. C., J. D. HARRIS, T. Q. TRINH, R. A. SISTON, and R. H. BROPHY. Prevalence of Chondral Defects in Athletes' Knees: A Systematic Review. *Med. Sci. Sports Exerc.*, Vol. 42, No. 10, pp. 1795–1801, 2010. **Purpose**: To determine the prevalence of full-thickness focal chondral defects in the athlete's knee. **Methods**: We conducted a systematic review of multiple databases, evaluating studies of the prevalence of articular cartilage defects in athletes. Because of the heterogeneity of data, a meta-analysis could not be performed. **Results**: Eleven studies were identified for inclusion (931 subjects). All studies were level 4 evidence. Defects were diagnosed via magnetic resonance imaging, arthroscopy, or both. Forty percent of athletes were professionals (NBA and NFL). The overall prevalence of full-thickness focal chondral defects in athletes was 36% (range = 2.4%–75% between all studies). Fourteen percent of athletes were asymptomatic at the time of diagnosis. Patellofemoral defects (37%) were more common than femoral condyle (35%) and tibial plateau defects (25%). Medial condyle defects were more common than lateral (68% vs 32%), and patella defects were more common than trochlea (64% vs 36%). Meniscal tear (47%) was the most common concomitant knee pathological finding, followed by anterior cruciate ligament tear (30%) and then medial collateral ligament or lateral collateral ligament tear (14%). **Conclusions**: Full-thickness focal chondral defects in the knee are more common in athletes than among the general population. More than one-half of asymptomatic athletes have a full-thickness defect. Further study is needed to define more precisely the prevalence of these lesions in this population. **Key Words:** ARTICULAR CARTILAGE DEFECT, MRI, ARTHROSCOPY, PATELLOFEMORAL, ACL, MCL, LCL, LESIONS

Articular cartilage defects of the knee demonstrate limited regenerative potential in response to injury and, therefore, have been implicated as a potential risk factor in the development of early-onset osteoarthritis (1,13,41). Chondral defects are seen in 34%–62% of knee arthroscopies (2,12,18,52), while full-thickness focal lesions of with an area of at least 1–2 cm^2 are seen in 4.2%–6.2% (range of prevalence among referenced studies) of all arthroscopies (2,12,18,52) in patients younger than 40 yr. These studies document the prevalence of chondral defects in all patients within the general population, athletes and nonathletes alike, of any age requiring knee arthroscopy for any reason. Younger patients with large, isolated, full-thickness defects represent those most amenable to cartilage repair or restoration with marrow stimulation techniques, osteochondral autograft transfer system (OATS/mosaicplasty), osteochondral allograft, or cell-based therapy with autologous chondrocyte implantation (ACI) (10,35).

The natural history of the isolated chondral defect and to what degree the isolated defect may become symptomatic is not completely understood (8). The presence of concomitant injuries, whether acute or chronic, further influences management of these lesions. Insufficiency of the anterior cruciate ligament (ACL) (19,45,51), deficiency of the menisci, and malalignment of both the patellofemoral and tibiofemoral compartments must be addressed during surgery (10,53). Intra-articular knee injuries are known to occur more frequently in an athletic population and may lead to degenerative changes in the knee (26). Compared with the general population, athletes place a higher demand on the knee and, as a result, are 12 times more likely to develop osteoarthritis (13,41). Epidemiologic data suggest that athletes subjected to both acute contact trauma and repetitive joint loading during pivoting and twisting are more likely to show signs of joint degeneration (13,41).

A recent systematic review of microfracture concluded that early treatment of chondral defects with microfracture was associated with positive clinical and histologic outcomes (36).

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Another systematic review (17b) reported that early treatment of defects with either ACI or microfracture was associated with positive clinical outcomes and earlier return to sport. Therefore, early diagnosis and treatment of chondral defects in the knee of the athlete may facilitate a quicker return to sport after injury and decrease the risk of developing osteoarthritis in the future (35). Although the prevalence of chondral defects in the general population, athletes and nonathletes together, has been well documented, the prevalence of chondral defects in an exclusively athletic population is currently unknown. The purpose of this systematic review was to report the prevalence of full-thickness chondral defects in athletes using the currently available evidence. We hypothesize that the prevalence of articular cartilage lesions in the athlete is higher than published standards for the general population.

METHODS

To determine the prevalence of chondral defects in athletes, we conducted a systematic review of levels 1–4 evidence as determined by the Oxford Centre for Evidence-Based Medicine (37). A literature search of PubMed, MEDLINE, EMBASE, The Cochrane Collaboration of Systematic Reviews, Cumulative Index for Nursing and Allied Health Literature, and SPORTDiscus was carried out on November 1, 2009, and repeated on November 2, 2009, to ensure accuracy. All articles were manually reviewed by the authors of this study, and references were reviewed for possible inclusion. If there was any disagreement among authors regarding inclusion of an article, the senior author (D.C.F.) made the final decision. The search terms were epidemiology, incidence, prevalence, occurrence, cartilage, chondral, defect, lesion, knee, athlete, and sport. Study heterogeneity precluded performance of a meta-analysis.

An initial search yielded 4752 citations. Limitation to the knee joint yielded 1082 citations, while further limitation to chondral defects involving the knee in athletes yielded 182 articles. For the purposes of this review, "athlete" was defined as a subject who trains and competes in games or exhibitions. Both competitive recreational and high-level (high school, collegiate, and professional) athletes were included. Elimination of articles appearing in more than one database yielded 173 unique citations. After further application of exclusion criteria, 10 articles were identified for possible inclusion (Fig. 1). Review of all references cited by these articles yielded an additional 11 articles for possible inclusion. Two studies documenting intra-articular findings identified exclusively during ACL reconstruction were excluded (22,39). One article was excluded because of failure of the data to adequately separate athletes and nonathletes included in the study (48). One study was excluded because it lacked tibiofemoral compartment imaging and only reported patellofemoral compartment magnetic resonance imaging (MRI) findings (21). Four studies (24,25,31,40) reported data on two identical patient populations, and two studies were kept for inclusion (24,31). One study was excluded because it only

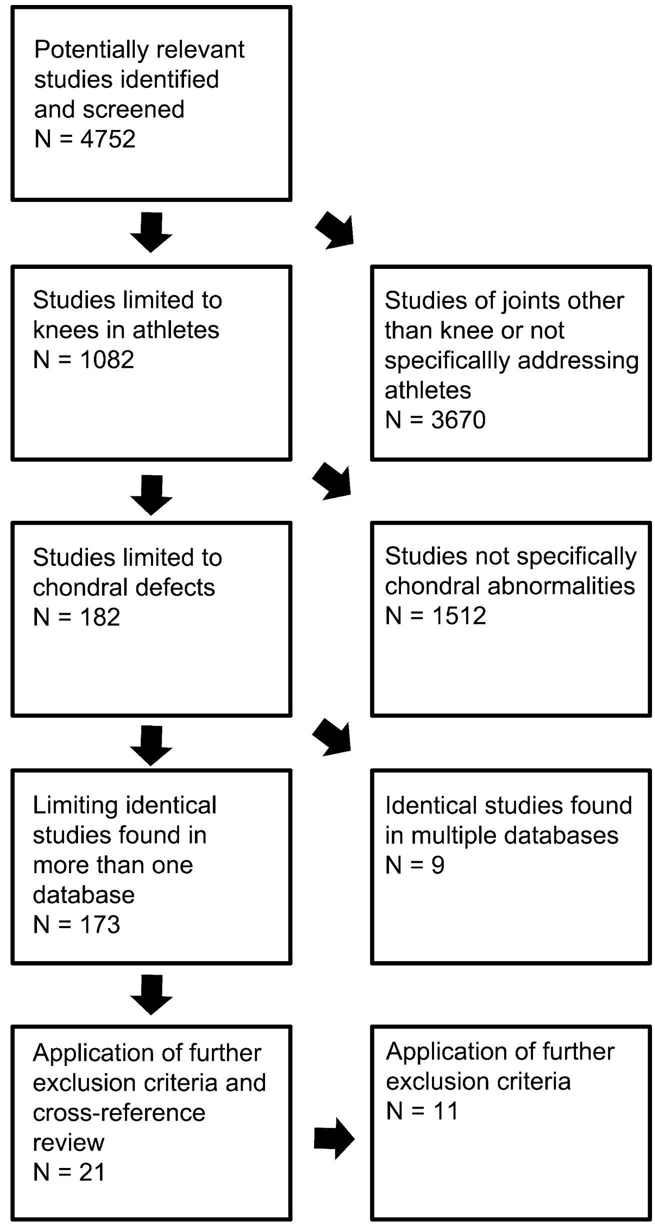

FIGURE 1—Application of exclusion criteria for study inclusion.

documented patients with osteoarthritis (26). Three studies were excluded because they did not report enough data of the subject sample population to calculate prevalence and they only reported those subjects with an already-identified chondral defect and failed to report those subjects within the same sample population without a chondral defect (6,27,33). Therefore, 11 studies were included in this systematic review (Tables 1–3) (3,5,23,24,30,31,42,43,46,47,49).

Description of defects within all studies included two arthroscopic classification systems: the arthroscopic system of Bauer et al. (4) and the modified system of Shariaree (44). The most common system currently used is that of Outerbridge (38). The Bauer system is a visual, qualitative arthroscopic classification system that grades traumatic lesions 1–4 (1 = linear crack, 2 = stellate fracture, 3 = flap, and

TABLE 1. Study demographics and defect characteristics.

	No. of Subjects (Knees)	Subjects with ≥1 Defect, *n* (%)	Defect Identification	Defect Classification (AKS)	Total No. of Defects
Bachmann et al. (3)	320 (320)	240 (75)	AKS, MRI	Modified Shariaree[a]	756
Bradley et al. (5)	332 (332)	8 (2.4)	MRI	NA	8
Kaplan et al. (23)	20 (40)	19 (48)	MRI	NA	31
Krampla et al. (24)	8 (8)	5 (63)	MRI	NA	5
Major and Helms (30)	17 (34)	6 (35)	MRI	NA	6
Marans et al. (31)	121 (128)	26 (21)	AKS	Bauer[b]	26
Schueller-Weidekamm et al. (42)	22 (22)	4 (18)	MRI	NA	4
Schueller-Weidekamm et al. (43)	26 (26)	7 (27)	MRI	NA	7
Shellock et al. (46)	29 (29)	6 (21)	MRI	NA	6
Stahl et al. (47)	22 (22)	7 (32)	MRI	NA	7
Walczak et al. (49)	14 (28)	7 (50)	MRI	NA	27

[a] Shariaree (44).
[b] Bauer et al. (4).
AKS, arthroscopy knee surgery; NA, not applicable.

4 = crater). The Shariaree modified system is also a qualitative arthroscopic classification system that stages acute cartilage lesions 1–4 (stage 1 = focal softening, stage 2 = superficial cracks and defibrillations, stage 3 = deep cartilage erosions, and stage 4 = focal total loss of cartilage). None of the included studies used the Outerbridge system or one of its modifications. The Outerbridge system (grades I–IV) uses a simple method of arthroscopic assessment of a lesion, especially for grades I (softening and swelling) and IV (full-thickness cartilage erosion to bone). However, grades II and III defects are partial-thickness and do not account for depth; rather, they are divided by a defect diameter less or greater than 0.5 inch, respectively. This system has proven reproducibility and reliability for grading chondral lesions of the knee (9,32).

Although many different MRI techniques have recently been developed with improved accuracy, sensitivity, and specificity, no standardized MRI classification has gained universal acceptance for description of focal cartilage injury, and thus, all studies reporting focal chondral injury diagnosed by MRI were included.

Inclusion criteria:

- English-language studies
- Levels 1–4 evidence
- Chondral defects identified by arthroscopy or MRI
- Studies investigating athletes

Exclusion criteria:

- Non–English-language studies
- Animal studies
- Level 5 evidence
- Studies investigating osteoarthritis (via x-ray diagnosis)
- Studies investigating volumetric chondral changes secondary to exercise
- Studies addressing chondral defects only seen exclusively during ACL reconstruction
- Studies reporting a sample population only of athletes with a known diagnosis of chondral defect in the knee and exclusion of those athletes within the same population without a chondral defect

RESULTS

Eleven studies were identified for inclusion. All included studies were case series (level 4 evidence). Tables 1, 2, and 3 include the following data: within all studies, there were 931 athletes (989 knees) identified, 732 of whom were men and 199 were women. The lack of reporting gender-specific data precluded an analysis of the effect of gender on defect prevalence. Average age of subjects was 33 yr (range = 26–47 yr). All knees were evaluated with arthroscopy (n = 128), MRI (n = 541), or both (n = 320). A total of 883 full-thickness chondral defects were reported, among 335 subjects, for an average of 0.89 lesions per knee. Therefore, the mean overall prevalence of full-thickness focal chondral defects in these athletes was 36% (range = 2.4%–75% between all studies). The median prevalence and mode across all studies was 32% and 21%, respectively. One study (31) used arthroscopy exclusively to identify chondral defects in

TABLE 2. Defect location per study.

	MFC, % (*n*)	LFC, % (*n*)	Trochlea, % (*n*)	Patella, % (*n*)	Tibial Plateau, % (*n*)
Bachmann et al. (3)	23 (177)	12 (88)	13 (100)	23 (177)	16 (119) MTP 13 (95) LTP
Bradley et al. (5)	NR	NR	NR	NR	NR
Kaplan et al. (23)	13 (4)	3.2 (1)	32 10	45 (14)	6.5 (2)
Krampla et al. (24)	NR	NR	NR	NR	NR
Major and Helms (30)	NR	NR	NR	NR	NR
Marans et al. (31)	85 (22)	15 (4)	0	0	0
Schueller-Weidekamm et al. (42)	NR	NR	NR	NR	NR
Schueller-Weidekamm et al. (43)	57 (4)		0	43 (3)	0
Shellock et al. (46)	NR	NR	NR	NR	NR
Stahl et al. (47)	29 (2)		14 (1)	43 (3)	14 (1)
Walczak et al. (49)	15 (4)	11 (3)	26 (7)	44 (12)	3.7 (1)

LFC, lateral femoral condyle; MFC, medical femoral condyle; NR, not recorded.

TABLE 3. Patient characteristics.

	Mean Age (yr)	Gender	Mean Weight, kg (BMI, kg·m^{-2})	Concomitant Injuries, % (*n*)	Mean Duration of Symptoms	Defect Etiology	Professional Athletes, % (*n*)	Recreational Athletes, % (*n*)
Bachmann et al. (3)	29.3	198 M/122 F	NR	79 (253) ACL tear; 39 (125) MCL/LCL tear; 62 (198) MM tear; 48 (154) LM tear	NR	79 sports, 13 MVC	2 (6)	98 (314)
Bradley et al. (5)	NR	332 M	NR	NR	NR	100 football (NFL Combine)	100 (332)	0
Kaplan et al. (23)	26.2	20 M	NR	20 (8) meniscal tears	All asymptomatic	100 basketball (NBA)	100 (2)	0
Krampla et al. (24)	37	8 M	NR	NR	6 subjects asymptomatic	100 marathon runners	0	100 (8)
Major and Helms (30)	NR	12 M/5 F	NR	24 (8) patellar tendinosis; 12 (4) discoid menisci	All asymptomatic	Basketball	0	100 (17)
Marans et al. (31)	32.8	81 M/40 F	NR	38 (76) meniscal tear; 14 (28) ACL tear; 48 plica, loose bodies, fat pad contusions	NR	100 racquet sports	NR	NR
Schueller-Weidekamm et al. (42)	32	16 M/6 F	66.3 ± 9.3 (20.5 ± 1.57)	NR	20 subjects asymptomatic	Marathon runners	0	100 (22)
Schueller-Weidekamm et al. (43)	33	19 M/7 F	66.7 ± 9.1 (21 ± 1.57)	NR	NR	Distance runners	0	100 (26)
Shellock et al. (46)	47	20 M/9 F	NR	3.4 (1) ACL; 3.4 (1) MCL tear; 3.4 (1) LCL tear; 14 (4) meniscal tear	13 subjects asymptomatic	Ironman triathletes	0	100 (22)
Stahl et al. (47)	34.0	12 M/10 F	72.2 ± 11.3	0	All asymptomatic	Marathon runners, recreational runners	0	100 (22)
Walczak et al. (49)	26.3	14 M	NR	Patellar and quadriceps tendinosis, loose bodies, bone island, nonossifying fibroma, meniscal tear, prepatellar bursitis	All asymptomatic	100 basketball (NBA)	100 (14)	0

F, female; LM, lateral meniscus; M, male; MM, medial meniscus; MVC, motor vehicle collision; NBA, National Basketball Association; NFL, National Football League.

the knee. The prevalence of full-thickness defects in this study was 21%. One study (3) used arthroscopy to confirm MRI-identified chondral defects, and nine studies (5,23,24, 30,42,43,46,47,49) used MRI exclusively to identify chondral defects. Therefore, the prevalence of full-thickness defects identified by MRI was 38%. No study reported mean defect size. Three-hundred nine defects were located in the femoral condyles (35%), 327 were located in the patellofemoral joint (patella and trochlea; 37%), and 218 were located in the tibial plateaus (25%). Five studies did not classify location of defects (3%; n = 29 defects not localized). Of those studies that subclassified defects on the femoral condyle (n = 303), 68% (n = 207) were medial and 32% (n = 96) were lateral. Of those studies that subclassified patellofemoral defects (n = 327), 64% (n = 209) and 36% (n = 118) were located on the patella and trochlea, respectively. Three studies reported mean patient weight or body mass index (BMI; weight range = 66.3–72.2 kg). The most common concomitant injuries identified included meniscal tear (n = 441), ACL tear (n = 282), and medial collateral ligament (MCL) or lateral collateral ligament (LCL) tear (n = 127).

Professional athletes. Forty percent (n = 372) (3,5,23,49) of all subjects in this review were professional (NFL and NBA) athletes. One study (5) documented chondral injuries from the NFL Combine database. The Combine is an invitation-only, 4-d event where elite college football players undergo professional football skills evaluation and medical evaluation. Bradley et al. (5) reported eight (2.4% of all participants) osteochondral defects (diagnosed by MRI) at the 2005 Combine. Two studies (23,49) documented chondral injuries from the NBA's team preseason evaluation. Kaplan et al. (23) evaluated 20 NBA players (40 knees) from 1996 to 1999 and reported a prevalence of articular cartilage lesions of 47.5% (diagnosed by MRI). Of all defects identified, 77% were located in the patellofemoral joint. Walczak et al. (49) reported that 50% of subjects had at least one articular cartilage defect, also primarily affecting the patellofemoral joint (70% of all defects).

Asymptomatic athletes. Fourteen percent (n = 132) (23,24,30,42,46,47,49) of all subjects in this review were asymptomatic before knee evaluation. Four studies (23,30, 47,49) only reported asymptomatic athletes (n = 73), and three other studies' subjects (24,42,46) contained a large proportion of asymptomatic athletes (n = 39). Three studies of asymptomatic athletes evaluated basketball players (23,30, 49), while the other four studies evaluated endurance runners (24,42,46,47). Among asymptomatic basketball players and runners, the prevalence of full-thickness focal chondral defects was 59% (range = 18%–63% between studies).

DISCUSSION

On the basis of published studies to date, the overall prevalence of focal chondral defects in the knee is 36% among all athletes and up to 59% among asymptomatic basketball players and runners. The prevalence of full-thickness focal chondral defects in athletes seems to be higher than that of the general population. Four studies in the literature report on more than 58,000 knee arthroscopies performed on the general population (2,12,18,52). Within these studies, "full-thickness articular cartilage defect" is defined as Outerbridge grade IV lesions (6051/31,516 subjects, 19% [12]; 3014/25,124 subjects, 12% [52]), full-thickness chondral or osteochondral (116/1000 subjects, 12%) (18), and localized full-thickness lesion without osteoarthritis (203/993 subjects, 20%) (2). Thus, the prevalence of arthroscopically detected "full-thickness articular cartilage defects" in the latter studies of the general population is 16% (9384/58,633 subjects). In patients younger than 40 yr without any other concurrent knee pathological finding and lesion size greater than 1–2 cm^2, the prevalence is 5% (2,12,18,52).

Intra-articular location-specific prevalence in athletes was concordant with findings seen in the general population (2,12,18,52). Medial femoral condyle and patellar defects have been shown to be more common than lateral femoral condyle and trochlear defects, respectively. Patellofemoral defects were seen more commonly in NBA players (23,49). This finding may be due to the increase in patellofemoral joint forces because of the strong extensor mechanism contraction during plyometric jump training and in jumping athletes (11). Repetitive stressing of the joint by jumping while asymptomatic may eventually lead to imbalance of patellofemoral homeostasis and defect production and progression (14). However, these findings among professional basketball players are limited by the small number of studies and subjects within the studies. Brophy et al. (6) reported all knee articular cartilage injuries in the NFL database from 1992 to 2006. One-hundred eighteen defects were identified (eight defects per year). Most lesions were seen in linemen (37%) and were located on the weight-bearing surfaces of the femoral condyles (54%). The mean BMI among football players in the latter study (6) (31 kg·m^{-2}) was higher than that found in other athlete groups (21 kg·m^{-2}) in other studies (42,43,47) in our review. Many other defect-specific parameters that potentially influence defect creation, progression, and response to surgical treatment (defect size, duration of symptoms before diagnosis, concomitant intra- and extra-articular knee injury, and previous surgeries) remain unanswered after this review.

Full-thickness chondral lesions may progress on the basis of a combination of stress concentration around the rim of a defect (17), subchondral bone structural changes (34), and intra-articular inflammatory cytokine concentration elevation (15). As this review and other studies (7,29,45,50,51) have demonstrated, chondral defects are commonly seen in conjunction with ACL insufficiency (30% of athletes in our review). Because the purpose of our systematic review was to report the prevalence of chondral defects in athletes and not the prevalence of chondral defects in patients with ACL insufficiency, studies that reported chondral defects in only an ACL-deficient population were appropriately excluded. Furthermore, the subject cohorts within these studies include both athletes and nonathletes alike. Up to 15 yr of follow-up of defects associated with ACL insufficiency has revealed that, if left without cartilage repair or restoration, clinical outcomes may be unaffected (45,51). A recent systematic review (7) of ACL reconstruction and concomitant articular cartilage injury has shown that articular cartilage defects are frequently seen at the time of ACL reconstruction (incidence 16%–46% in acute injury). This latter review also reported that combined ACL reconstruction and ACI or osteochondral autograft can demonstrate good short-term results. Nevertheless, ACL injury increases risk of osteoarthritis, regardless of reconstruction (7,28). Whether progression to degenerative joint disease results from cartilage defects sustained at the time of initial injury or is due to other intra-articular processes after injury or reconstruction has yet to be established. Only six studies in our review reported concomitant injuries in addition to chondral pathology. These studies varied considerably in defining concomitant injury. Further, there were no correlations reported between any concomitant injury and the presence of a chondral defect. Further long-term data are needed to assess more precisely the effect of ACL injury and concomitant chondral injury on tibiofemoral joint health.

The high prevalence of focal chondral defects in the asymptomatic athlete identified in our review makes the management of these lesions particularly challenging. These findings are limited by the low proportion of subjects within our review who were asymptomatic. Notwithstanding, the natural history of chondral defects in the knee has not been well established. Furthermore, the degree to which these lesions are symptomatic and the factors that influence defect progression and symptom are also unknown. Although treatment decision making for the symptomatic athlete is multifactorial, the optimal approach to the asymptomatic athlete is unknown.

Although more and better treatment options are becoming available for the surgical treatment of chondral defects, the optimal indications for such treatment, particularly of asymptomatic lesions, are still being determined. A recent survey (6) conducted among team physicians for the NFL has shown that, for all lesions under all conditions, the most popular treatment approach is microfracture (43.3%), followed by debridement (31.4%), then nonoperative management (13.2%), then mosaicplasty (6%), osteochondral allograft (3.5%), and cell-based therapy (ACI; 2.6%). This survey also showed that size was the most important factor in decision making: larger lesions (>5 cm^2) were most frequently treated with microfracture (43.2%) and debridement (32.7%) but rarely nonoperatively (3.7%), whereas smaller lesions (<1 cm^2) were most commonly treated with microfracture (43.8%) and debridement (30.2%) but, much more often, were managed nonoperatively (22.6%). Osteochondral autograft, allograft, and cell transplantation were never used for lesions <1 cm^2 but were used in 8.7%, 7.1%, and

4.5%, respectively, for lesions >5 cm^2. Patellofemoral lesions were never treated with allograft or cell transplantation.

A recent systematic review from our institution has demonstrated better clinical outcomes after ACI and OATS versus microfracture in athletes (17b). This review also concluded several findings: the overall rate of return to sport after any surgical technique was 66%, the timing of return to sport was fastest after OATS and slowest after ACI, results after microfracture tended to deteriorate with time and were worse with larger defects, and rate of return to sport was generally lower after microfracture versus ACI or OATS. Furthermore, defect size <2 cm^2, preoperative duration of symptoms <18 months, no previous surgical treatment, younger patient age, and higher preinjury and postsurgical level of sport all correlated with improved outcomes after cartilage repair, especially ACI. Although many key findings were identified, the methodological quality of those studies included and cartilage repair studies overall continues to be poor (20).

Limitations of this review include those derived from the studies it reports, which were primarily retrospective, a relatively small series of a sport-specific population, and mostly from basketball and running. The patients in these studies were older than typical college and high school athletes. The gold standard for diagnosis of chondral defects in the knee is arthroscopy, which was performed only in two studies because of obvious ethical limitations of invasive evaluation. Although MRI techniques are highly variable, their accuracy, sensitivity, and specificity are improving and approaching that of arthroscopy (16). Within our review, Bachmann et al. (3) reported that, with increasing defect severity on arthroscopic evaluation, the sensitivity increases. With grade I, II, III, and IV defects, the sensitivity increases from 14% to 32% to 94% to 100%, respectively. Although the latter study was published in 1999, it was published in the journal *European Radiology*, and the MR techniques were advanced for their time and similar to those used in contemporary sports medicine practice. Nevertheless, detection bias was present in 9 (82%) of 11 studies using MRI for diagnosis. Furthermore, classification systems for the defects evaluated were not uniform in both MRI and arthroscopic studies. This dissimilarity precludes a precise comparison between studies. Although studies uniformly report gender within subject demographics, they do not report gender-specific defect prevalence. This is a valid topic that warrants further investigation. The range of prevalence was quite wide, and more and larger studies are needed. The ideal patient population to address the primary question would be a cross-sectional evaluation of a wide range of athletes, symptomatic and asymptomatic, at different levels of many sports with a noninvasive, highly accurate, modality, such as MRI. Confounding variables in the studies within this review (concurrent intra-articular injuries such as meniscal tear and ACL tear) add performance bias. However, given the relative frequency of concomitant articular cartilage and other intra-articular knee injury, our conclusions may be more practical and applicable to our evaluated population.

CONCLUSIONS

The overall prevalence of full-thickness focal chondral defects in knees of athletes was 36%, higher than that found in the general population. Patellofemoral defects were more common than femoral condyle defects. Medial condyle defects were more common than lateral and patellar defects more common than trochlear. Meniscal tear was the most common concomitant knee pathological finding, followed by ACL tear, then MCL or LCL tear. Although limited by the low methodological quality of studies included, this systematic review suggests that full-thickness focal articular cartilage defects are more common among athletes compared with the general population.

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