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Clinical Outcome of Isolated Subcortical Trabecular Fractures (Bone Bruise) Detected on Magnetic Resonance Imaging in Knees*

Rick W. Wright,†‡ MD, Mary Ann Phaneuf,§ MD, Thomas J. Limbird,§ MD, and Kurt P. Spindler,§ MD

From the †Department of Orthopaedic Surgery, Washington University School of Medicine, Barnes-Jewish Hospital, St. Louis, Missouri and §Vanderbilt Sports Medicine Center, Vanderbilt University, Nashville, Tennessee

ABSTRACT

Isolated subcortical trabecular bone injury (bone bruise) has rarely been described. Our purpose is to report a series of patients who had a history of traumatic injury, knee effusion, normal radiographs, and initial equivocal physical examination for ligament and meniscal integrity, and who were found to have isolated injury of the trabecular bone on magnetic resonance imaging. We evaluated demographic data, physical examination findings, radiographs, magnetic resonance imaging, and clinical outcome for 23 patients. Follow-up data included time to return to preinjury activity level, International Knee Documentation Committee activity level rating before and after injury, and postinjury Lysholm scores. All magnetic resonance imaging scans were negative for associated grade III meniscal lesions and ligament injury. Time to return to preinjury activity level was under 7 months in 96% of the patients. Postinjury International Knee Documentation Committee rating was unchanged in 91% of patients. Postinjury Lysholm score was 90 or more in 91% of patients. We propose that the recognition of these injuries is important because magnetic resonance imaging can distinguish them from meniscal or ligament injury requiring surgical intervention (arthroscopy). If detected on magnetic resonance imaging as an isolated injury, surgical arthroscopy is unnecessary since these patients can be expected to recover well in the short term with restricted weightbearing and initial activity modification.

Bone bruises are a heterogeneous group of injuries ranging from diffuse trabecular involvement to localized injury contiguous to the subchondral plate with cortical fracture and extension to the articular surface. Magnetic resonance imaging has led to recognition of these lesions, especially in association with ligament injury. Bone bruises associated with ACL ruptures and medial collateral ligament injuries have been previously reported.[4,7,8,10,12,13,15] The clinical significance, long-term consequences to articular cartilage (such as degeneration), and the most appropriate initial treatment (weightbearing status) await long-term follow-up studies. Few studies have clinically described isolated subcortical trabecular bone injury as the initial injury in acute knee trauma in the athlete.[8–11,13,17] These few reports have consisted of radiographic descriptions without clinical detail of treatment or clinical outcomes. The purpose of this paper is to report a series of patients who had a history of traumatic injury, knee effusion, normal radiographs, and initial equivocal physical examinations for ligament and meniscal integrity, who were found to have isolated injury of the trabecular bone on MRI.

MATERIALS AND METHODS

We evaluated demographic data, physical examination findings, radiographs, MRI scans, and clinical outcome for 23 patients with isolated subcortical trabecular bone in-

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‡ Address correspondence and reprint requests to Rick W. Wright, MD, Department of Orthopaedic Surgery, Washington University School of Medicine, One Barnes-Jewish Hospital Plaza, St. Louis, MO 63110.

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jury who were seen for evaluation of an acute knee injury between December 1990 and July 1997. Follow-up data were obtained between April 1995 and January 1998. Demographic data recorded included age, sex, mechanism of injury, activity at the time of injury, date of injury, date of MRI, and date of final evaluation. Initial and final physical examination findings were noted. Subjective follow-up included time to return to preinjury activity level, International Knee Documentation Committee (IKDC) activity level rating both before and after injury, and postinjury Lysholm scores.

Radiographs, including at least AP and lateral views, obtained when the patients were initially examined were read as negative in all patients. An MRI scan was obtained in all cases and evaluated by an experienced musculoskeletal radiologist. Many of these patients were high-level athletes desiring aggressive diagnosis and treatment for their injuries to allow early return to activity. The MRI scan was obtained to fully evaluate patients with normal radiographs, effusions, and signs and symptoms consistent with possible meniscal or cruciate ligament injuries. The MRI examination consisted of oblique sagittal T2-weighted, sagittal intermediate spin density, and T2-weighted images, and T1-weighted coronal images on a 1.5-T magnet.[16] Sagittal gradient echo images were obtained in some patients. The T1-weighted images were performed with a repetition time (TR) of 600 msec and echo time (TE) of 15 msec. The T2-weighted images were performed with a TR of 2000 to 2500 msec and a TE of 80 to 90 msec. Intermediate spin density images had a TR of 2000 to 2500 msec and TE of 20 msec. Evidence of ligament injury, meniscal injury, and subcortical trabecular bone injury was recorded. In addition to being prospectively read by experienced musculoskeletal radiologists, all scans were reviewed at the time of initial patient evaluation by three authors (RWW, KPS, TJL), and diagnosis and treatment were determined.

In addition, all scans were retrospectively reviewed by a senior author as well as by a second orthopaedic surgeon (TJL and RWW, respectively), and bone bruise types were classified based on Vellet's classification for this type of injury.[16] A reticular lesion was defined as consisting of serpiginous regions of diminished T1-weighted signal intensity distant from the subchondral bone plate. A geographic lesion was defined as a discrete focus of low signal intensity on a T1-weighted image that was confluent and demonstrated contiguity to the subchondral plate. A linear subcortical fracture was defined as a lesion with a discrete linear zone of diminished signal intensity on the T1-weighted images that was usually less than or equal to 2 mm wide, with a sharp zone of transition to the adjacent marrow fat. An impaction fracture was defined as a lesion with depression of the articular surface in conjunction with a geographic type lesion. An osteochondral fracture was defined as a geographic lesion with a discrete low signal intensity interface marginating the lesion from the surrounding trabecular bone and communicating with the joint space.

All patients seen within 2 weeks of injury were treated with either protected weightbearing or restriction from running, jumping, or other impact activity. The patients were treated with gradual return to activity when the pain and effusion had subsided. Those patients seen after 2 weeks were started on a gradual return-to-activity program with weightbearing as tolerated. Weightbearing was allowed for all patients when it could be accomplished without pain. A rehabilitation program consisting of general range of motion and quadriceps and hamstring muscle strengthening was used in conjunction with a return to sport-specific functional activities. The patient's Vellet classification did not change his or her treatment plan.

RESULTS

Twenty-three patients with isolated subcortical injury were identified between December 1990 and July 1997. The average age of the patients was 25.6 years (range, 12 to 55; SD, 11.6), with the majority of patients (78%, 18 of 23) younger than 30 years of age at the time of injury. There were 15 men and 8 women. All patients had a history of knee trauma, with the most common mechanism being hyperextension (30%, 7 of 23), followed by twisting injury (26%, 6 of 23), or a fall (17%, 4 of 23). Fifteen (65%) were contact-related injuries. Sports were the activity at injury in 83% of patients (19 of 23). All patients initially had an effusion and equivocal examination for cruciate ligament laxity or meniscal integrity with a subsequent normal repeat examination on the follow-up visit once initial guarding from acute trauma, effusion, and range of motion improved. No patient demonstrated varus or valgus instability at the time of initial or repeat examination. No patient demonstrated physical examination signs of ACL laxity at follow-up visits.

All MRI scans were obtained within 3 weeks of injury, with an average of 7.6 days. All MRI scans were negative for associated grade III meniscal lesions and complete ACL or PCL rupture or collateral ligament injury.

Vellet's classification system for describing a bone bruise type was used. According to this system, there were seven geographic fractures (Fig. 1), seven osteochondral fractures, three linear subcortical fractures, three reticular fractures, and no impaction fractures. Three patients' MRIs were not available for retrospective bone bruise type classification (Table 1).

Follow-up ranged from 4 months to 4.5 years, with an average of 21.3 months. Nineteen of 23 final evaluations were performed at 1 year or more from the time of injury (Table 2). The range of time to return to preinjury activity level averaged 3.2 months, with 91% (21 of 23) returning at 6 months or less. One patient, an elite-level triathlete, returned to his preinjury activity level after 12 months. Time to return to activity was not dependent on the Vellet classification of bone bruise type. Average return to activity for reticular-type injuries was 3.0 months; for geographic injuries, 3.1 months; for linear subcortical injuries, 3.0 months; and for osteochondral fractures, 3.4 months.

The preinjury IKDC activity rating was strenuous in 61% of patients (14 of 23), moderate in 22% (5 of 23), light in 4% (1 of 23), and sedentary in 13% (3 of 23) (Table 2). The postinjury rating was unchanged in 91% (21 of 23)

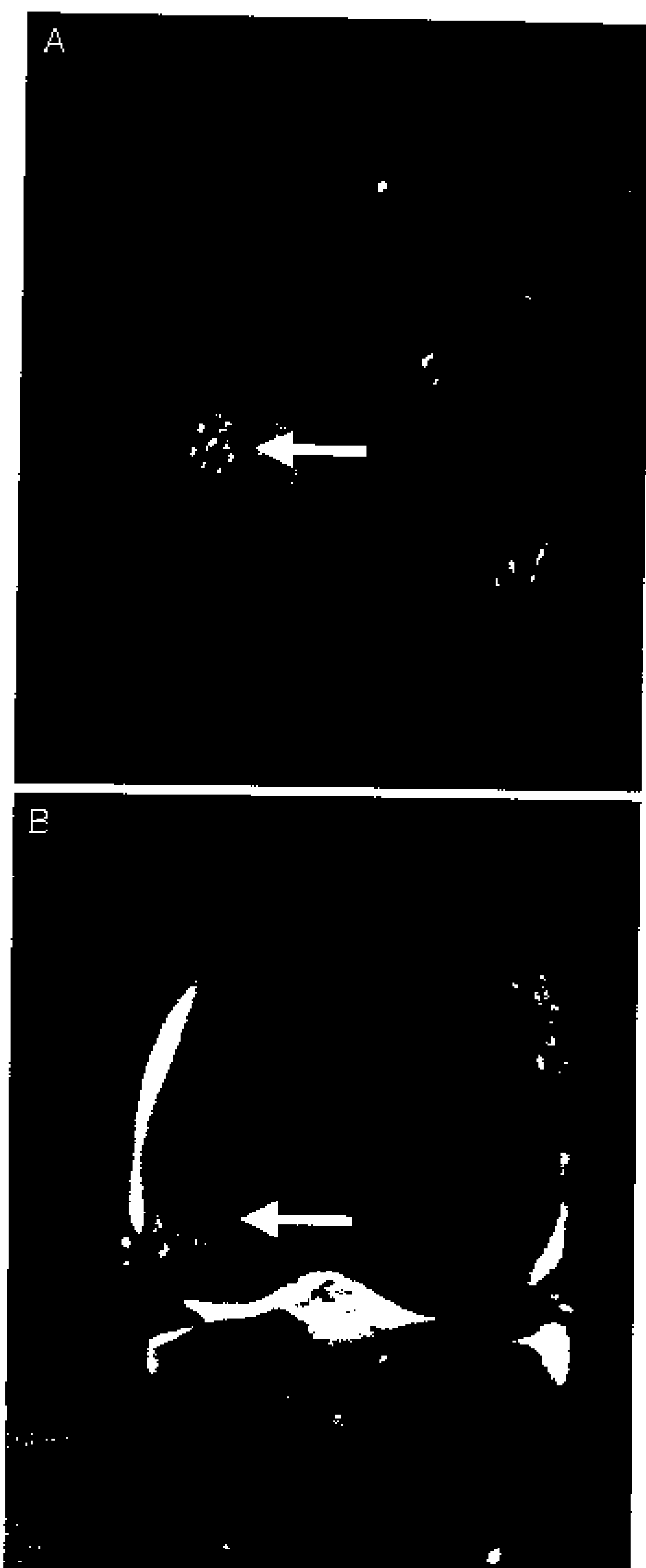

Figure 1. A, sagittal view of a geographic fracture, T2-weighted scan. B, coronal view of a geographic fracture, T2-weighted scan.

(Table 2). All patients but one, 93% (13 of 14), maintained their preinjury strenuous activity rating (IKDC) at the time of follow-up evaluation. Percent performance of the injured knee relative to the noninjured knee was 100% in 22 of 23 patients before injury (Table 2). This remained at 95% to 100% after injury in 15 of 23 patients (65%), declined by 10% in 3 (13%), by 15% to 20% in 2 (9%), and by more than 20% in 3 (13%). Despite the fact that there was a decrease in nine patients' subjective impression of the performance of their injured knee compared with the contralateral knee, only two patients had a decrease in activity level.

The postinjury Lysholm score was greater than or equal to 90 in 21 of 23 patients (91%). All patients reported full range of motion at the time of follow-up.

DISCUSSION

It is accepted that osseous subcortical lesions that appear as an area of intermediate or low signal intensity on T1- or intermediate-weighted MR images and increased signal on T2-weighted images represent localized areas of acute hemorrhage or edema and are secondary to microfracture of the adjacent medullary trabeculae.[4,6,13,17] Marks et al.[6] investigated bone scintigraphic findings in 13 patients who had subchondral injury demonstrated on MRI. All showed focal bone activity by scintigraphy. These results, in addition to acute resolution of medullary changes on T2-weighted images noted by Speer et al.,[12] support interpretation of these changes as representing acute injury, as opposed to a chronic process. Despite the ability of MRI to detect trabecular bone injury, the clinical significance and long-term sequelae of this type of injury remain poorly defined.

Studies that have retrospectively correlated arthroscopic findings with a bone bruise on MRI have noted variable association with gross articular cartilage abnormality. Mink and Deutsch[8] and Lynch et al.[4] retrospectively attempted to correlate findings. Lynch et al. found 28% of type I and type II lesions (11 of 39) were associated with changes in the overlying cartilage. Seventy-five percent of type III lesions (9 of 12) were associated with changes; however, these lesions occurred in patients with degenerative changes on plain radiographs. A type I finding was defined as a diffuse, often reticulated signal intensity loss in the metaphyseal and epiphyseal regions. A type II loss was associated with an interruption in the smooth, back cortical line. A type III finding was defined as a profound signal intensity loss primarily restricted to the immediate subcortical region. Although clinical histories were incomplete, only 8 of 245 grade III lesions were associated with clear-cut traumatic events. Although Vellet et al.[15] performed a prospective study of 120 patients who had acute hemarthrosis, all of whom underwent MRI and arthroscopy, they did not specifically address correlation between osteochondral lesions noted on MRI with the site of the bone bruise when observed arthroscopically. Eighty-six of these 120 patients were found to have occult fractures on MRI. They do report a subset of 21 patients with normal articular cartilage at the time of initial ar-

TABLE 1
Demographics and Injury Mechanism of the Patients in this Study

Age	Sex	Injury mechanism	Activity at injury	Time to MRI[a] (days)	MRI injury type[a]
17	F	Hyperextension	Basketball	5	V
19	F	Fall	Skiing	4	V
40	F	Twist	Horse riding	10	V
20	M	Hyperextension	Football	1	II
18	F	Twist	Soccer	7	III
17	M	Impact	MVA	14	II
25	M	Hyperextension	Basketball	2	Unavailable
18	F	Unknown	Soccer	14	V
24	M	Sliding	Softball	12	I
33	F	Twist	Skiing	21	V
22	M	Hyperextension	Football	3	II
25	M	Hyperextension	Basketball	1	V
35	M	Hyperextension	Basketball	16	Unavailable
28	M	Impact	No sport	8	II
48	M	Fall	No sport	4	V
55	F	Fall	No sport	1	III
20	M	Fall	Hockey	14	II
20	M	Impact	Hockey	7	Unavailable
15	M	Twist	Soccer	7	I
27	M	Hyperextension	Football	1	II
26	M	Twist	Football	1	III
24	M	Impact	Football	1	II
12	F	Twist	Soccer	21	I

[a] Vellet's classification of bone injury on MRI; I = reticular; II = geographic; III = linear subcortical; IV = impaction fracture; V = osteochondral fracture.

throscopy who underwent repeat MRI at 6 to 12 months after injury. On follow-up MRI scans of these 21 patients, 67% demonstrated osteochondral sequelae at the site of initial geographic injury, with no sequelae noted at their associated reticular signal changes sites.

Spindler et al.[13] prospectively determined that two findings on MRI were significantly associated with lateral femoral condyle articular cartilage injury identified at the time of arthroscopy: a thin and impacted subchondral bone in the presence of a bone bruise and abnormal car-

TABLE 2
Functional Results of the Patients in this Study

Follow-up (months)	IKDC				Postinjury Lysholm score	Return to preinjury activity level (months)
	Activity level[a]		Performance compared with uninjured knee (%)			
	Preinjury	Postinjury	Preinjury	Postinjury		
4	1	1	100	100	100	2.5
39	2	2	100	95	95	3
18	4	4	100	85	90	3
12	1	1	100	100	100	2
36	1	1	100	100	100	6
9.5	2	2	100	75	76	0.5
18	1	1	100	100	100	4
30	1	3	100	80	95	6
18	1	1	100	90	95	3
12	3	4	100	30	90	6
18	1	1	100	100	100	1
30	1	1	100	100	100	1
54	1	1	100	70	95	6.7
30	1	1	100	100	96	12
54	4	4	100	90	90	2.5
18	4	4	90	80	61	1.5
13	2	2	100	95	95	3
18	1	1	100	100	100	1.5
10	2	2	100	100	100	3
15	1	1	100	100	100	1.5
18	1	1	100	100	100	1.5
12	1	1	100	100	100	1.5
4	2	2	100	100	100	3

[a] 1, strenuous; 2, moderate; 3, light; 4, sedentary.

tilage signal. However, no studies documented clinical outcomes at follow-up of these MRI findings. Our study demonstrates that isolated lesions have a favorable short-term recovery with restricted weightbearing and initial activity modification.

Several studies indicate that blunt articular cartilage injury, even when not readily visible on initial gross inspection, may have significant effects on future cartilage metabolism.[1–3,5,14] The long-term functional significance of trabecular injury on MRI remains to be determined by evaluation of associated degenerative changes at a minimum 5- to 10-year follow-up.

This is the first report of initial MRI findings and clinical outcome of isolated cases of bone injury without associated ligament injury. We propose that this entity needs to be included in the differential diagnosis of the acutely traumatized knee in athletes and, when found, has a favorable short-term prognosis without need for arthroscopy to evaluate for an intraarticular cause of effusion.

CONCLUSIONS

We postulate the group of injuries previously described as bone bruises represents a spectrum from medullary trabecular fracture to osteochondral fracture with cortical disruption. Protected weightbearing until walking pain-free with a gradual return to functional sport activities in these patients allowed a return to activity by an average of 3 months. We propose that it is important to recognize these injuries and that MRI is a useful adjunct to distinguish them from meniscal or ligament injury requiring surgical intervention. If detected on MRI as an isolated injury, surgical arthroscopy is unnecessary for further evaluation to routinely rule out meniscal or ligament abnormality. These patients can be expected to recover well with short-term restricted weightbearing and initial activity modification. Further extended follow-up is required to define the long-term significance of these injuries.

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