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The Natural History of Bone Bruises

A Prospective Study of Magnetic Resonance Imaging-Detected Trabecular Microfractures in Patients with Isolated Medial Collateral Ligament Injuries

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ABSTRACT

We conducted a prospective study to evaluate bone bruises, or trabecular microfractures, associated with isolated medial collateral ligament injuries. Magnetic resonance imaging was performed on 65 patients with isolated medial collateral ligament injuries determined by physical examination and imaging studies. Of these 65 patients, 29 (45%) had associated trabecular microfractures. Follow-up images were completed at various intervals on 24 of these 29 patients (83%). Complete resolution of these lesions was observed in all cases. This process appears to occur as a result of gradual diffusion over a period of 2 to 4 months. Bone bruises associated with medial collateral ligament injuries are approximately one-half as common as bone bruises associated with anterior cruciate ligament injuries. However, medial collateral ligament-associated trabecular microfractures may be a better natural history model because these injuries are treated nonoperatively.

Bone bruises are trabecular microfractures that result from traumatic injuries to bone, most commonly about the knee. This clinical entity has been well described in patients with associated ACL injuries.[11,17] However, the natural history of bone bruises and the ultimate fate of these lesions remains largely unknown. In a preliminary study, we noted that bone bruises can also occur in conjunction with isolated medial collateral ligament (MCL) injuries.[8] The presence of bone bruises associated with these injuries has also been reported by other authors.[9,16,17] However, no one has classified these lesions or provided follow-up magnetic resonance imaging (MRI) data on these patients.

Because MCL injuries are treated nonoperatively, unlike many ACL injuries, a detailed investigation of bone bruises associated with these collateral ligament injuries provides a better natural history model. We therefore undertook a prospective study of bone bruises in patients with isolated MCL injuries to 1) define the prevalence of bone bruises in patients with these injuries, 2) determine the natural history of these bone bruises, and 3) propose a classification scheme for bone bruises associated with MCL injuries.

MATERIALS AND METHODS

We performed a prospective study of 73 consecutive skeletally mature patients who came to the U.S. Air Force Academy hospital between August 1, 1993, and July 31, 1995, with suspected isolated grade 2 or 3 MCL injuries determined by physical examination. All patients were examined by either of two of us (MDM or DTH) who are board-certified orthopaedic surgeons with fellowship training in sports medicine. All patients were evaluated with plain radiographs and clinical examinations during their first visits to our clinic. The only patients enrolled in the study were those who had negative findings on plain radiographs, histories of valgus or rotational knee injury, localized medial-side knee tenderness, no significant effusion, greater than 5 mm of valgus instability at 30° but not at 0° of knee flexion, and no anteroposterior or rotational instability. No patient with an isolated grade 1 MCL injury (less than 5 mm of valgus laxity on physical exami-

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TABLE 1
Grading of MCL Tears Based on MRI Scans[a]

Grade	Description
1	Edema and hemorrhage within the ligament Ligament continuity intact
2	Localized hemorrhage Partial ligament disruption
3	Marked hemorrhage and thickening Complete disruption

[a] Adapted from Mink and Deutsch.[10]

TABLE 2
Bone Bruise Classification Based on MRI Scans

Type	Description	Number
I	Lateral tibial plateau (LTP) only	6
II	Lateral femoral condyle (LFC) only	10
III	LTP and LFC	8
IV	LTP fracture	3
V	Other	2

nation) was included in the cohort. Grade 1 MCL injuries were excluded because a preliminary study at the Air Force Academy hospital demonstrated a bone bruise prevalence of 0% (based on MRI scans) in 17 consecutive patients with grade 1 MCL injuries.

Magnetic resonance imaging was performed within 2 weeks of injury in all 73 patients. Imaging was accomplished using a dedicated coil and a 1.5-T unit, the GE Signa 1.5 (General Electric Medical Systems, Milwaukee, Wisconsin). All MRI scans were interpreted by a board-certified skeletal radiologist (JRO). Medial collateral ligament injuries were classified using the MRI scheme of Mink and Deutsch[10] (Table 1). Trabecular microfractures, when identified, were classified based on their locations and the extent of injury. Data were also recorded regarding any other knee abnormality (such as meniscal tears) noted on the magnetic resonance image. Sixty-five of 73 patients (89%) had MRI findings consistent with a grade 2 or 3 MCL injury. Eight patients had grade 1 MCL injuries determined by MRI and were excluded from the cohort.

All patients were treated with DonJoy range of motion knee braces (Smith & Nephew Inc., DonJoy Div., Carlsbad, California) locked with an arc of 30° to 60° of flexion for the initial 3 weeks, followed by unrestricted motion in the brace for an additional 3 weeks. Partial weightbearing was permitted as tolerated during the initial 3 weeks; full weightbearing was permitted after 3 weeks. No patient in the current series underwent any operative intervention during the period of the study. Serial physical examinations were performed on all patients until resolution of

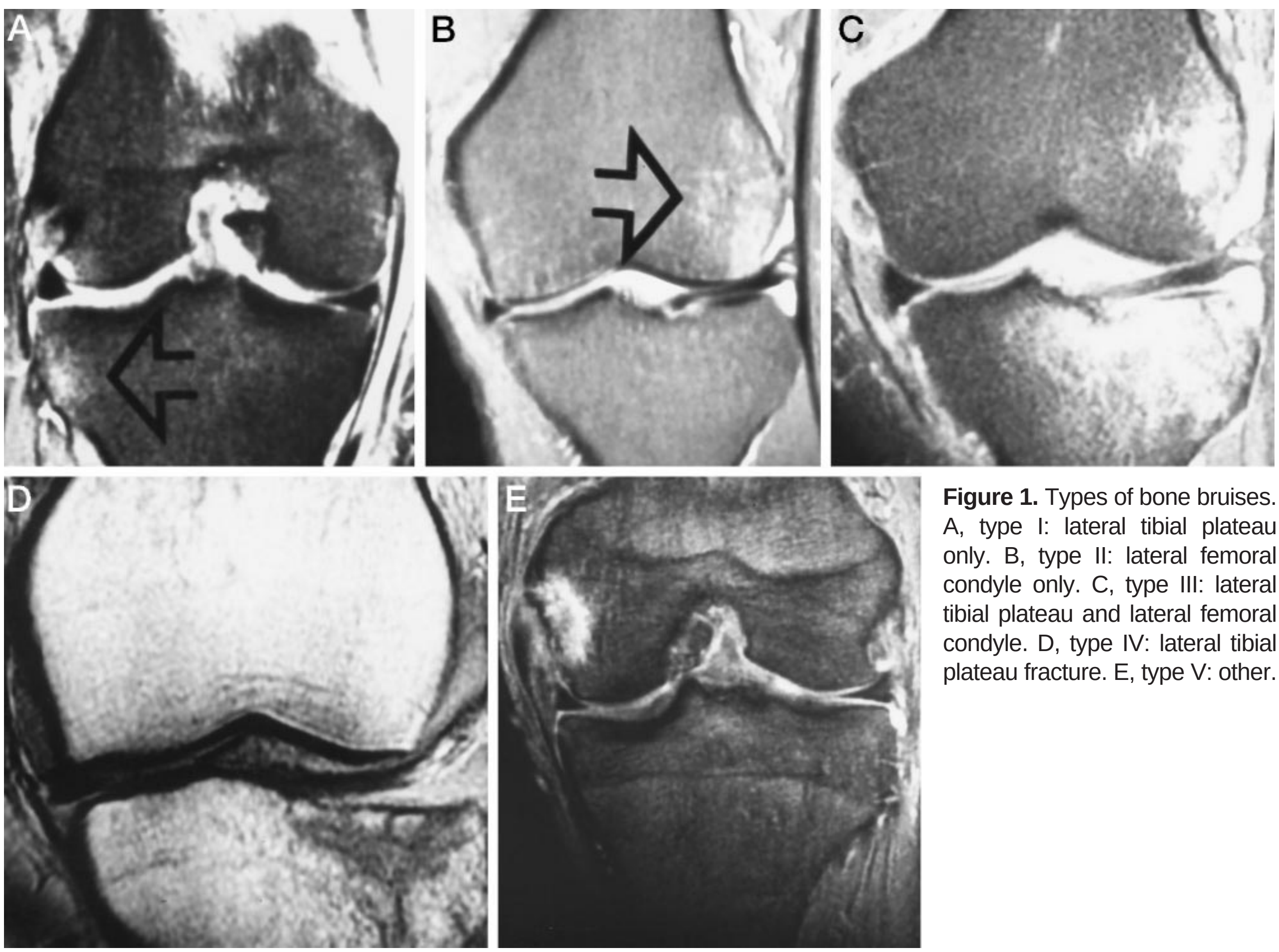

Figure 1. Types of bone bruises. A, type I: lateral tibial plateau only. B, type II: lateral femoral condyle only. C, type III: lateral tibial plateau and lateral femoral condyle. D, type IV: lateral tibial plateau fracture. E, type V: other.

TABLE 3
Trabecular Microfracture Follow-up MRI Data

Patient No.	Sex	Age	Microfracture type	Interval after injury (months)	MRI finding
02	M	18	II	2	Diffusing
				4.5	Resolved
06	M	18	I	12	Resolved
07	M	16	III	6	Resolved
11	M	46	I	12	Resolved
14	M	19	V	7	Resolved
15	M	18	III	2	Diffusing
				5	Resolved
16	M	20	III	Lost to followup	
21	M	20	II	10	Resolved
22	M	18	II	Lost to followup	
23	F	20	I	5	Resolved
24	M	17	II	10	Resolved
25	M	35	IV	11	Resolved
26	M	22	II	9	Resolved
39	F	34	I	11	Resolved
40	M	14	II	Lost to followup	
41	F	30	IV	12	Resolved
42	M	35	I	1.5	Diffusing
				5	Resolved
43	M	20	III	2	Near-resolved
				4	Resolved
46	M	21	I	Lost to followup	
48	M	18	II	8	Resolved
49	M	21	III	2.5	Resolved
50	M	22	II	3	Resolved
51	F	51	IV	9	Resolved
54	M	37	II	6	Resolved
55	M	20	II	4	Resolved
61	F	34	III	9	Resolved
62	M	28	V	Lost to followup	
63	F	20	III	5	Resolved
64	M	32	III	10	Resolved

their symptoms. Follow-up MRI studies were performed, when possible, on patients whose initial MRI scans demonstrated trabecular microfractures.

RESULTS

Sixty-five patients were studied; 54 men and 11 women. Thirty-seven right and 28 left knees were involved. The average age of all 65 patients with clinical and MRI evidence of grade 2 or 3 MCL injuries was 24.8 years (range, 14 to 52). Trabecular microfractures were identified in 29 of the 65 patients (45%). These lesions were classified based on their locations and extent of injury as listed in Table 2 and illustrated in Figure 1.

Follow-up MRI scans were performed in 24 of the 29 patients (83%) with bone bruises demonstrated in the initial imaging study. Imaging could not be performed in five patients who were lost to followup. The findings of follow-up MRI scans in patients with bone bruises is shown in Table 3. Complete resolution of the trabecular microfractures seen on the initial images occurred in all 24 cases available for followup. Based on the data in Table 3, the lesions appear to resolve over the 2- to 4- month period after injury; the mechanism appears to be a gradual diffusion (Fig. 2).

Magnetic resonance imaging showed that MCL injuries occurred at the femoral attachment in 51 patients, and at the tibial attachment in 14 patients; there were no midsubstance tears. Meniscal tears were noted in 10 patients. Most of these were partial-thickness peripheral tears of the medial meniscus. None of these tears were symptomatic after resolution of the MCL injury. Partial PCL injuries were noted on initial MRI scans in three patients. None of the patients with PCL injuries had positive posterior drawer test results, and none developed any symptoms during the course of the study.

DISCUSSION

Treatment of isolated MCL injuries has evolved. Early studies of these injuries were affected by the lack of a precise diagnostic standard, as subjective measurements based on clinical laxity were used.[2,3] Later studies have used diagnostic arthroscopy to identify "isolated" tears.[5,7] Most current studies advocate nonoperative treatment for isolated MCL injuries and report good results of this treatment.[5,7,15]

Several studies have demonstrated high sensitivity with the use of MRI to diagnose MCL injuries.[12,14,16] However, as Mirowitz and Shu[12] point out, the results of

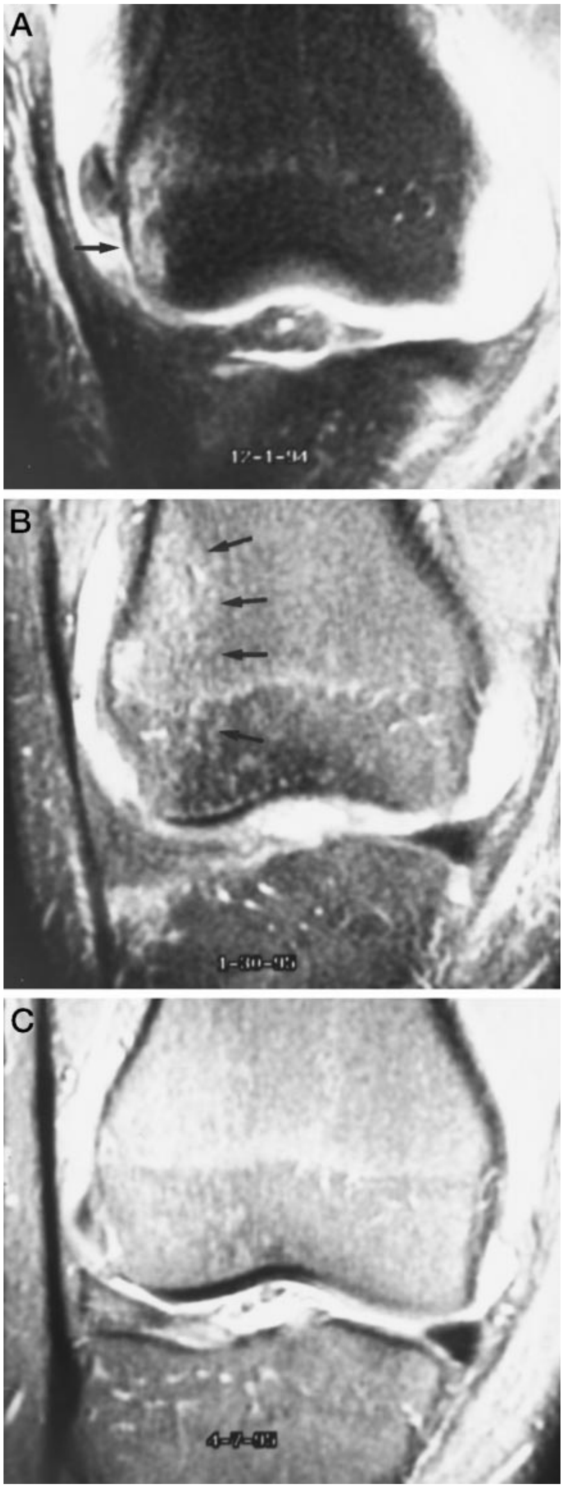

Figure 2. Resolution of a bone bruise shown by serial coronal fast spin echo proton density fat-saturated images of Patient No. 2 (right knee). A, initial image taken 1 week after the initial injury shows a localized bone bruise involving the lateral aspect of the lateral femoral condyle (arrow). B, image taken 2 months later shows diffusion of the localized bruise (arrows). C, image 4.5 months after original injury shows complete resolution of the bone bruise.

clinical evaluation represent a somewhat weak standard by which to judge the efficacy of MRI for detection of collateral ligament injuries. The MCL tears in this study, based on MRI scans, were primarily on the femoral side. It is interesting that most reports of MCL injuries in the literature fail to indicate the location of the injury. Although experimental findings suggest that the femoral attachment is more susceptible to injury,[6] and our experience also suggests that femoral-side injuries occur more commonly, others disagree.[16] Indelicato (personal communication, 1997) proposes that tibial-side injuries are more common in contact injuries and that femoral-side lesions are more common in noncontact injuries. Most authors agree that midsubstance injuries are uncommon, and our findings support this observation.

Bone bruises associated with ACL tears have been extensively investigated.[11,17] Recent studies have suggested that some of these lesions may have evidence of osteochondral sequlae more than 5 years after the initial lesion (K. Faber et al., unpublished data, 1996). Johnson and colleagues have performed biopsies in patients with these lesions and demonstrated histologic changes (chondrocyte and matrix degeneration) and biochemical changes in the cartilage overlying bone bruises (D. Johnson et al., unpublished data, 1996).

The prevalence of trabecular microfractures in patients with ACL injuries appears to be more than 70% to 80%.[4,17] The prevalence of these microfractures in the present study of isolated MCL injuries is slightly less than half this. This may be related to the fact that more force is associated with ACL injuries than with MCL injuries or to the fact that the bone bruises associated with MCL injuries, in general, are not subchondral. These findings would also suggest that these lesions are less severe than those associated with ACL injuries.

Medial collateral ligament injury-associated bone bruises have only recently been described[9,16,18]; however, there appears to be a lack of consensus regarding the most common locations for these lesions. Mink[9] has noted that these bone bruises most commonly involve the lateral side of the tibia or femur, which concurs with our findings. More recently, Schweitzer et al.[16] have suggested that they are more commonly located within the medial femoral condyle. The incidence reported by Schweitzer and colleagues (24%) was substantially lower than ours, but this may be due to the nature of their study, which was based on MRI scans. Studies reported in the radiology literature sometimes suffer from the problem of being anecdotal or retrospective, and they often do not include any clinical evaluation. Furthermore the studies' populations have mixed ligament injuries, and none of these studies include follow-up evaluation.

The MCL injury-associated bone bruises we have noted apparently occur as a result of an impaction force opposite the ligamentous injury (a sort of contrecoup event). These lesions are usually more diffuse and less localized than bone bruises associated with ACL injuries. They appear to be benign and generally resolve over a period of 2 to 4 months.

The most severe of these injuries, type IV, are actual fractures of the lateral tibial plateau. All three of the patients with type IV injuries had normal plain radiographs, and therefore the findings of fractures on MRI scans was unexpected. It is interesting that all three patients in this group were older than the average patient age (30, 35, and 51), and two of the three patients (Nos. 41 and 51) were women. Perhaps these patients had weaker, or more osteopenic, bones that predisposed them to more severe injuries, despite the fact that their plain radiographs did not demonstrate any abnormalities. Another issue is whether these patients should be treated with prolonged nonweightbearing or any changes to the normal MCL injury protocol. Of course, without the use of MRI, the injuries in this group of patients would have gone undetected.

It would have been ideal to perform follow-up MRI studies on each patient at precise intervals after injury. However, this was not possible because of scheduling and other conflicts. Nevertheless, the majority of patients with trabecular microfractures underwent follow-up studies after their initial injuries. Several of these patients had serial studies, demonstrating resolution within 4 months. The only other study demonstrating follow-up MRI results, that we are aware of, evaluated a "defined subset" of 21 patients (of 120 in the cohort) at 6 to 12 months after their original injuries.[17] That study demonstrated "evidence of osteochondral sequelae" but resolution with no apparent sequelae at the site of the associated localized bone bruise in all cases. Our follow-up studies also demonstrated complete resolution of all reticular lesions, but we did not note any osteochondral sequelae in any of our patients, including those patients with lateral tibial plateau fractures (type IV lesions).

Before this study, we had noted that some patients with MCL injuries had complained of lateral-side joint pain for several weeks after injury. In fact, one of us (DTH) performed diagnostic arthroscopy on three such patients, with operative findings demonstrating no intraarticular abnormalities. In retrospect, it is likely that these patients had lateral-side trabecular microfractures that may have caused pain. Therefore, it seems prudent to observe patients with MCL injuries (and no obvious intraarticular abnormalities on physical examination) and lateral-side knee pain for at least 3 to 4 months before considering arthroscopic evaluation.

The high proportion of men in this study is a result of the study population. A majority of patients in this study were from the United States Air Force Academy, an institution that is predominately male. This fact also accounts for the relatively young age (average, 24.8 years) of the study cohort.

Magnetic resonance imaging was used in this study to evaluate bone bruises associated with MCL injuries. We caution against the routine use of MRI in evaluating knee disorders. O'Shea et al.[13] have recently demonstrated that careful clinical examination is more valuable than MRI in the evaluation of acute knee injuries. However, several investigators have emphasized the importance of ensuring that MCL injuries are truly isolated before proceeding with nonoperative treatment.[1,5,7] Magnetic resonance imaging may be helpful in those cases where this determination is difficult.

Medial collateral ligament-associated trabecular microfractures may be different from ACL-associated trabecular microfractures. Nevertheless, in this study these injuries were all treated nonoperatively, and thus may offer a better model for natural history studies. Even the most severe, type IV, lesions appeared to resolve without any sequela.

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