Magnetic Resonance Imaging Follow-up Study of Bone Bruises Associated With Anterior Cruciate Ligament Ruptures

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Purpose: The purpose of this study was to perform a magnetic resonance imaging (MRI) follow-up study of bone bruises in a group of patients with acute anterior cruciate ligament (ACL) ruptures that were reconstructed and followed-up for a minimum of 2 years. **Type of Study:** Cohort study. **Methods:** The study group included 21 patients with a mean age of 31 years whose initial MRI scans showed associated bone bruises. Patients were included if they had an acute isolated ACL tear, no documentation of an episode of repeated injury to the affected knee during the follow-up period, and no evidence of cartilaginous injury at the time of arthroscopy. All patients had preoperative MRI scans and underwent arthroscopic ACL reconstruction using a bone–patellar tendon autograft an average of 2 months after injury. The preoperative MRI scans were analyzed using a 3-level grading system based on the appearance and location of bone bruises. A second MRI of the knee was obtained from 24 to 64 months postoperatively (average 34 months). The presence of resolution of bone bruises was determined and correlation with clinical scoring established. **Results:** This study showed resolution of all type I lesions and 91% of type II lesions (10 of 11). In all type III lesions, an articular cartilage thinning and depression was observed after 2 years of follow-up. In 15 patients (71%), MRI showed that the bone bruises had resolved without apparent sequelae. In the remaining 6 patients (29%), sequelae of the osteochondral lesion were evident on MRI. **Conclusions:** According to our clinical data, there was no correlation between scores obtained from patients with resolved lesions against those with osteochondral sequelae. Although long-term clinical implications of these findings are uncertain, a severe occult osteochondral lesion sustained at the time of ACL rupture seems to be persistent on MRI even after a successful reconstruction. **Key Words:** Bone bruise—Anterior cruciate ligament—Magnetic resonance imaging—Knee.

The rupture of the anterior cruciate ligament (ACL) is frequently associated with damage of other structures within the knee. Magnetic resonance imaging (MRI) is a useful diagnostic aid for ACL ruptures and related injuries.[1] Bone bruises or microtrabecular fractures detected with MRI and usually occult in radiographic studies, have been described with high frequency in patients with acute ACL lesions.[2-6] Several studies have suggested that these abnormal MRI signals are caused by the original impact of the femoral cartilage to the tibia during the traumatic event.[7] Despite the high prevalence of these so-called bone bruises with ACL ruptures, little is known about the clinical consequences of these findings.[8] The purpose of this study was to perform MRI follow-up of bone bruises in a group of patients with an acute ACL rupture that was reconstructed and followed-up for a minimum of 2 years.

METHODS

The study group included 21 patients, 15 men and 6 women, with a mean age of 31 years (range, 20 to 58 years), whose initial MRI scans showed associated

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0749-8063/01/1705-2483$35.00/0

doi:10.1053/jars.2001.23581

bone bruises. Patients were included if they had an acute isolated ACL tear, no documentation of an episode of repeated injury to the affected knee during the period of follow-up, and no evidence of cartilaginous injury at the time of arthroscopy. Those with osteochondral abnormalities identified on plain radiographs and at arthroscopic examination were excluded.

All patients had preoperative MRI scans and underwent arthroscopic ACL reconstruction using a bone–patellar tendon autograft an average of 2 months after injury. Preoperative MRI scans were analyzed using a 3-level grading system based on the appearance and location of bone bruises. Type I was defined as diffuse signal with change of medullary component, often reticular and distant from the subjacent articular surface (Fig 1). Type II was defined as localized signal with contiguity to the subjacent articular surface. They are usually crescentic lesions with variable thickness (Fig 2). Type III was defined as disruption or depression of the normal contour of the cortical surface, often associated with a type II lesion (Fig 3).

At a minimum of 2 years after the original injury (range, 24 to 64 months, average 34 months) a second MRI was obtained; the presence or resolution of the bone bruises was determined and correlation with clinical scoring established. Patients were clinically evaluated according to the standard evaluation form developed by the International Knee Document Committee (IKDC). In addition, on each patient, KT-1000 arthrometric measurements were performed (MedMetric, San Diego, CA). A clinically stable knee was defined as having a solid endpoint on the Lachman test, absent pivot shift, and 3 mm or less of anterior translation with the KT-1000 arthrometer. An unstable knee showed at least 1 of the following parameters: positive Lachman, positive pivot shift, or an anterior tibial displacement on KT-1000 greater than 3 mm of difference.

The MRI scans were performed with either a 1.0-Tesla or a 1.5-Tesla superconducting magnet. In all patients, sagittal and coronal imaging of contiguous sections 3- to 5-mm thick was performed with a repetition time (TR) of 2,600 msec, an echo time (TE) of 17/119 msec, a 15-cm field of view, a 256 × 250 matrix, and with a TR of 400 msec, a TE of 18 msec, a 15-cm field of view, and a 256 × 200 matrix, respectively.

Preoperative and follow-up MRI scans were evaluated by one of the authors without knowledge of the clinical outcome of patients. Bone bruises showed decreased signal intensity on T1-weighted images and most of the lesions increased signal intensity on T2*-weighted images (gradient echo).[9] Images were evaluated with bone sequences or proton density and on different planes.

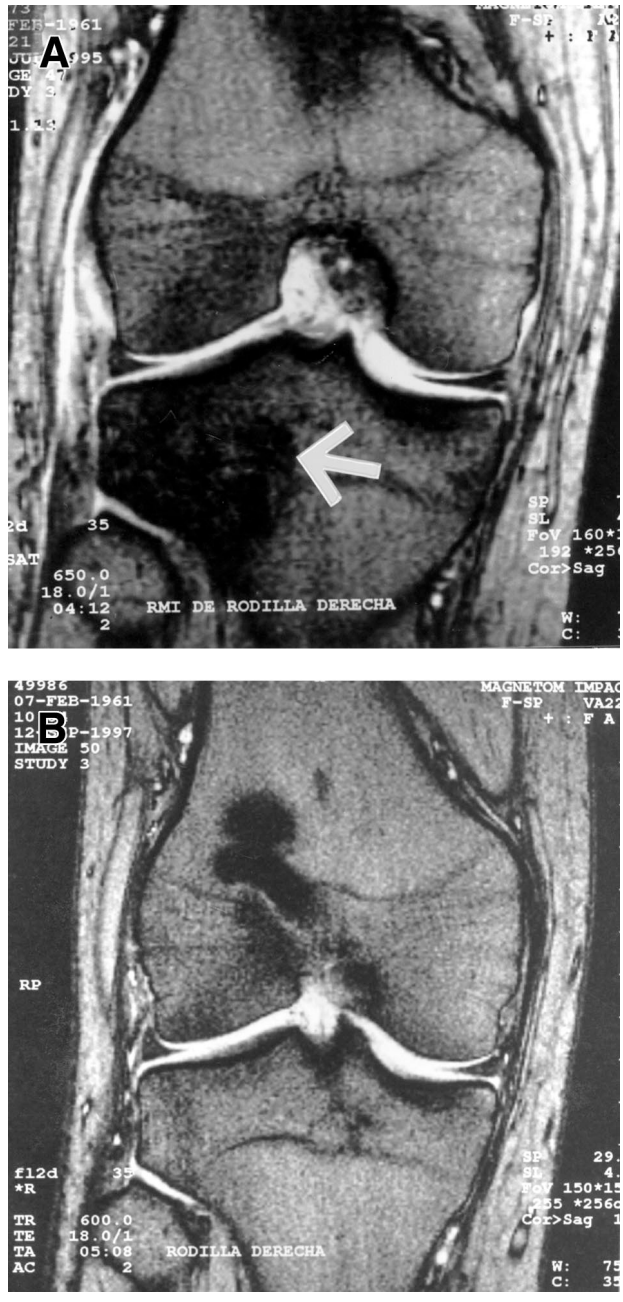

FIGURE 1. (A) Coronal image showing bone bruise in the lateral tibial plateau (type I). (B) Repeat MRI 2 years later showing resolution of this lesion.

RESULTS

There were 29 bone bruises identified on preoperative MRI scans in 21 patients. According to the

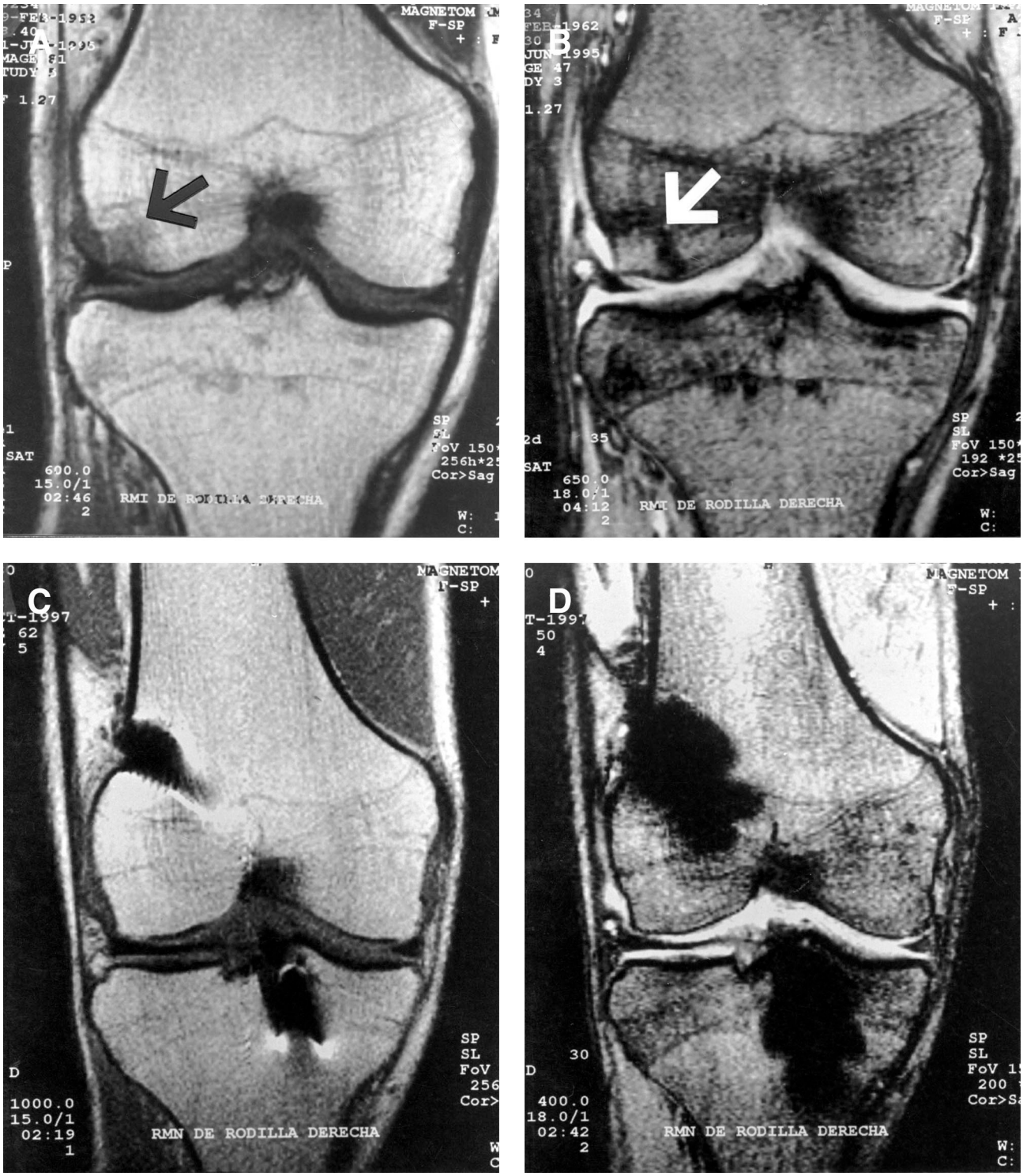

FIGURE 2. (A, B) Coronal T1- and T2*-weighted images (gradient echo) show bone bruise of the lateral femoral condyle (type II). (C, D) No apparent osteochondral sequelae at 2-year follow-up. Note the metallic artifact.

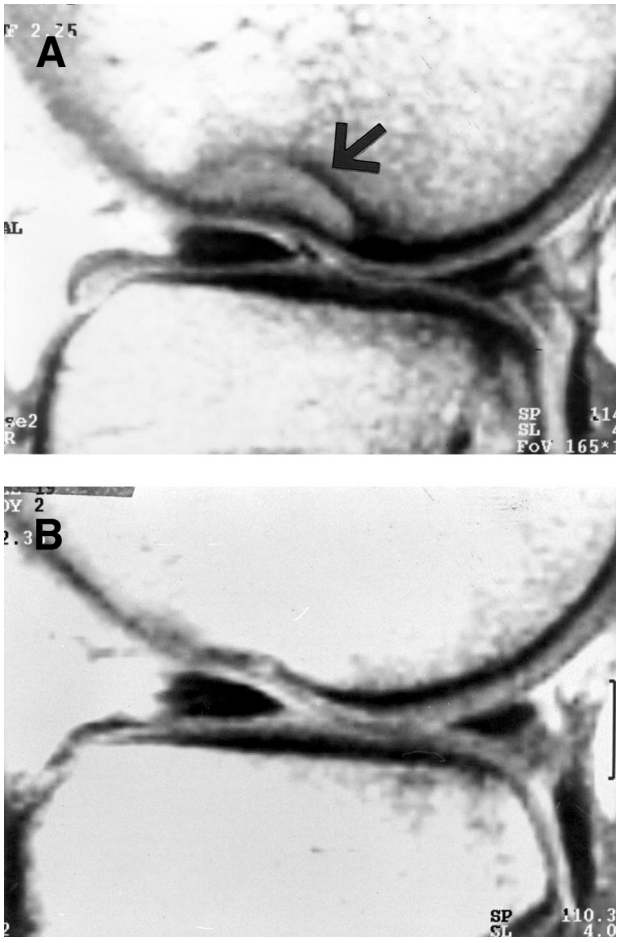

FIGURE 3. (A) Sagittal image of crescentic lesion (type III) abutting the femoral articular surface. (B) Repeat MRI 3 years later showing resolution of the medullary component but residual depression and thinning of the cartilage surface.

3-level grading system used, 13 lesions were classified as type I, 11 as type II, and 5 as type III (Table 1). The majority of type I lesions were located in the lateral tibial plateau and the type II and III lesions in the lateral femoral condyle (Table 2).

From the original 24 type I and type II bone bruises, only 1 type II lesion was still present at the second MRI; the remaining 23 resolved spontaneously. On the contrary, all 5 patients with type III lesions had evidence of persistent abnormality on MRI scans, consisting of cartilage thinning or cortical depression. In 15 patients (71%), the bone bruises had resolved without apparent sequelae on the MRI. In the remaining 6 patients (29%), sequelae of the osteochondral lesion were evident on MRI.

TABLE 1. *Prevalence of Osteochondral Lesions on MRI*

Type of Bone Bruise	No. of Lesions Preop	No. of Lesions Postop
Type I	13	0
Type II	11	1
Type III	5	5

TABLE 2. *Distribution of the Lesions*

Location	Type I	Type II	Type III	No. of Lesions
Lateral femoral condyle	1	10	5	16
Medial femoral condyle	—	1	—	1
Lateral tibial plateau	11	—	—	11
Medial tibial plateau	1	—	—	1

The final score on the IKDC standard evaluation form showed that 9 patients had a normal knee, 10 patients a nearly normal knee, and 2 had an abnormal knee. Of the 15 patients who had no lesions on follow-up MRI scans, 14 had a normal or nearly normal knee and 1 had an abnormal knee. In the group of 6 patients with persistence of lesions, 5 had a normal or nearly normal knee and 1 had an abnormal knee. Using the criteria for knee stability described previously, 18 patients had a stable knee and 3 an unstable knee. These last 3 patients had resolved bone bruises without apparent sequelae on the MRI. There was no correlation among findings on the follow-up MRI scans and follow-up physical examination, stability of the knee, or IKDC scores.

DISCUSSION

The long-term success of an ACL reconstruction depends not only on restoring knee stability and function but also in preventing degenerative changes. It has been speculated that bone bruises present on MRI scans in patients with ACL ruptures might be related to potential articular degenerative lesions.[10,11] It is possible that some of those subchondral bone injuries heal as fractures with callus formation, and may result in stiffer than normal subchondral bone. Decreased compliance of subchondral bone might require the articular cartilage to absorb more of the compressive forces experienced by the joint and may possibly lead to arthritic changes. Also, repeated episodes of subluxation in unstable knees can cause cartilage damage with chondrolysis and cell death leading to a degenerative joint disease.[12]

Several studies have been published reporting the

incidence and classification of bone bruises,[13] but few of them included follow-up MRI scans or clinical correlation. In a study including 21 patients followed-up for 6 to 12 months, postoperative MRI was performed to evaluate the resolution of the lesions. The authors concluded that all type I lesions tend to spontaneously resolve. However, 66% of type II lesions remained, leading to subchondral sclerosis, cartilage thinning, osteochondral defect, or cortical impaction.[14] Two additional studies reporting on series of about 20 patients after ACL reconstruction concluded that bone bruises are generally progressive lesions that might be the precursors of symptomatic arthritis. It was also concluded that, although a significant number of patients with these lesions can be expected to develop progressive articular cartilage abnormalities, case by case predictions based on initial MRI findings would be unreliable.[15,16]

Few studies including isolated cases of histology of these lesions have been published. Only 1 study, reporting on a series of 10 patients, showed that lesions with contiguity to the subchondral bone (type II) found on MRI indicate substantial damage to the normal articular cartilage homeostasis and that chondrocytes had a limited capacity to heal and a decrease in viability. The authors of this study suggested that large type II lesions should be an indication to alter the current treatment protocols.[17]

We have evaluated 21 patients with 29 previous osteochondral lesions after an average of 34 months from injury. If we analyzed the location of lesions, our data supported the findings of other authors who noted that bone bruises with ACL ruptures were predominant in the lateral side of the joint.[18,19] This study showed the resolution of all type I lesions and 91% of type II lesions (10 of 11). In all type III lesions, articular cartilage thinning and depression was observed after 2 years of follow-up.

According to our clinical data, there was no correlation between scores obtained from patients with resolved lesions against those who had osteochondral sequelae. Some of these injuries may damage the metabolic processes that maintain articular cartilage homeostasis and may be the precursor of early degenerative changes. However, several other factors may be considered in relation to the development of degenerative arthritis after an ACL rupture.[20] Although long-term clinical implications of these findings are uncertain, a severe occult osteochondral lesion sustained at the time of ACL rupture seems to be persistent on MRI, even after a successful reconstruction.

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