Bone bruise of the knee

Histology and cryosections in 5 cases

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We evaluated the histopathologic and cryosectional appearance of bone bruise injuries of the knee detected on MRI. Histologic evaluation of bone biopsies from 3 patients revealed microfractures of cancellous bone, edema and bleeding in the fatty marrow. Between intact lamellar bone trabecules, fragments of hyaline cartilage mixed with highly fragmented bone trabecules were found.

Postmortem specimens were obtained from 2 more patients, killed in motor vehicle accidents. MRI revealed bone bruise injuries of the lateral femoral condyle and of the lateral tibial plateau in 1 knee and anterior cruciate ligament disruption, a medial meniscus tear and bone bruise injury of the tibial plateau and of the lateral femoral condyle in the other specimen. The specimens were embedded in physiologic saline solution and frozen to –30 ° C. By rotationcryotomy, 1 mm slices were removed from the surface of the specimens and documented on photographs. Subchondral lesions and bleeding were found, corresponding to the MR images.

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Mink and Deutsch (1989) clarified bone bruise of the knee on MR imaging. The injury is not evident on plain radiographs. T1-weighted images showed a geographic and nonlinear area of signal loss involving the subcortical bone. On T2-weighted images, most of the lesions had increased signal intensity. The articular cartilage was normal. Since then, bone bruise injuries have been reported frequently in the knee (Mink and Deutsch 1989, Vellet et al. 1991, Murphy et al. 1992, Stallenberg et al. 1993, Stein et al. 1995, Zeiss et al. 1995, Rangger et al. 1996) and also in the wrist, the calcaneus, the foot and ankle, and in the hip (Kier et al. 1991, Laorr et al. 1995, Shih et al. 1995, Soudry and Mannting 1995).

We have found no reports on the histology of bone bruise lesions. We report 5 cases with histology or cryosectional investigations.

Patients and methods

3 patients without a history of trauma (1 woman aged 22 years, 2 men aged 40 and 28 years) underwent arthroscopy for a suspected meniscus injury 4 weeks, 5 weeks and 8 weeks after the onset of pain. No previous surgery had been performed. Anteroposterior and lateral weight-bearing radiographs of the involved knee and an axial view of the patella were normal. MR imaging performed before surgery revealed a bone bruise in the lateral tibial plateau of 2 patients, and in the anterior central part of the tibial plateau in the third patient (Figure 1). During arthroscopy, subchondral biopsies for histologic evaluation were obtained with a cannulated drill through a separate incision. All patients were informed and gave written consent to the biopsies. At arthroscopy, in 2 patients the articular surfaces, the ligaments, and the menisci were found intact. In the third patient, tears in the medial and lateral meniscus were treated by partial meniscectomy. These patients form part of a prospective series of MRI investigations before arthroscopy (Rangger et al. 1996).

Specimens were obtained from another 2 patients, who died only days after motor vehicle accidents. Clinical examination after admission to the hospital and immediately after the patients had died, suggested anterior cruciate ligament rupture in one and intact cruciate ligaments in the other knee. Plain radiographs were normal. Both postmortem specimens immediately underwent MRI evaluation. They were then placed in physiologic saline solution and frozen to –30 °C. Using a rotating shaft with blades, 1 mm slices were cut from the surface of the frozen specimens and photographed (Kathrein et al. 1996).

MRI was performed with various supraconducting magnets (0.5–1.0 Tesla) and various pulse sequences,

Figure 1. MR imaging (T2*) demonstrates bone bruise of the tibial plateau (arrow).

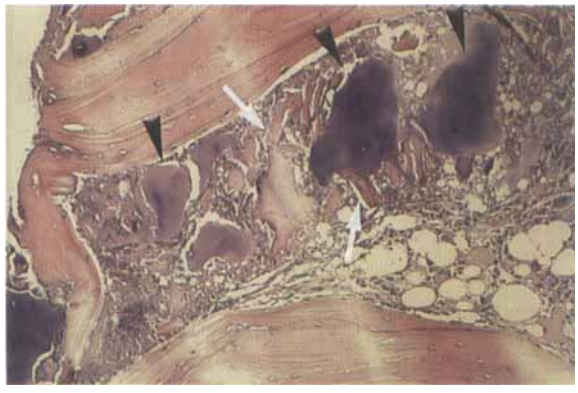

Figure 2. Histologic evaluation demonstrates microfractures of cancellous bone (light arrow), fragments of hyaline cartilage (black arrow) between intact lamellar bone trabecules, and new bone formation.

utilizing at least a T1-weighted sequence in 2 planes and a T2-weighted sequence in 1 plane. In every case, a dedicated surface coil was used.

Results

Histologic investigation revealed microfractures of cancellous bone and edema as well as bleeding in the fatty marrow in the 3 arthroscopy patients (Figure 2). Between intact lamellar bone trabecules, necrosis of the fatty marrow could also be found, due to protrusion of fragments of hyaline cartilage mixed with highly fragmented bony trabecules.

MRI of one of the postmortem knee specimens revealed an anterior cruciate ligament rupture, a tear of the medial meniscus and bone bruise injuries of the medial and lateral tibial plateau and of the lateral femoral condyle. MRI of the other specimen demonstrated bone bruise injuries of the lateral tibial plateau and the lateral femoral condyle. Rotationcryotomy showed a displaced bucket handle tear of the medial meniscus, disruption of the anterior cruciate ligament in the first specimen and the extent of the subchondral bony injuries in both specimens in corresponding areas, diagnosed as bone bruise on MRI (Figure 3).

Discussion

The words bone bruise, bone contusion, occult fracture and occult osseous lesion have been used synonymously for areas in cancellous bone, showing low signal intensity on T1-weighted and high signal intensity on T2-weighted MRI (Mink and Deutsch 1989, Deutsch et al. 1990, Kier et al. 1991, Stallenberg et al. 1993, Escalas and Curell 1994, Laorr et al. 1995, Shih et al. 1995, Stein et al. 1995, Zeiss et al. 1995). It has been suggested that they represent a spectrum of radiographically occult bone injuries, ranging from bleeding, infarction and edema to microscopic compression fractures of cancellous bone (Kier et al. 1991, Zeiss et al. 1995). Bone bruise injuries of the knee, without associated meniscoligamentous injuries, such as we found in 2 of our patients, have been reported before (Mink and Deutsch 1989, Vellet et al. 1991, Rangger et al. 1996). Most authors consider the lesions to be caused by a fracture. However, no injuries have been evaluated previously with histology or cryosection.

Thompson et al. (1991) subjected the canine patellar joint to standardized transarticular loading. Fractures in the zone of calcified cartilage with minimal damage to the articular cartilage surface and clefts in the subchondral bone were observed. Vener et al. (1992) found in 9 of 15 canine metacarpophalangeal and metatarsophalangeal joints loaded from 1.9 to 2.8 kN that the cartilage surface was not grossly fractured but cracks in the zone of calcified cartilage and subchondral bone were commonly identified by scanning electron microscopy. At higher loads, intraarticular fractures occurred. Escalas and Curell (1994) applied loads to rabbit knees. They detected edema without bleeding and intact subchondral bone at light microscopy in biopsies obtained from lesions classified as a so-called reticular type of occult bone injury on MRI. We observed microfractures of cancellous bone, bleeding and edema in the absence of damage to the

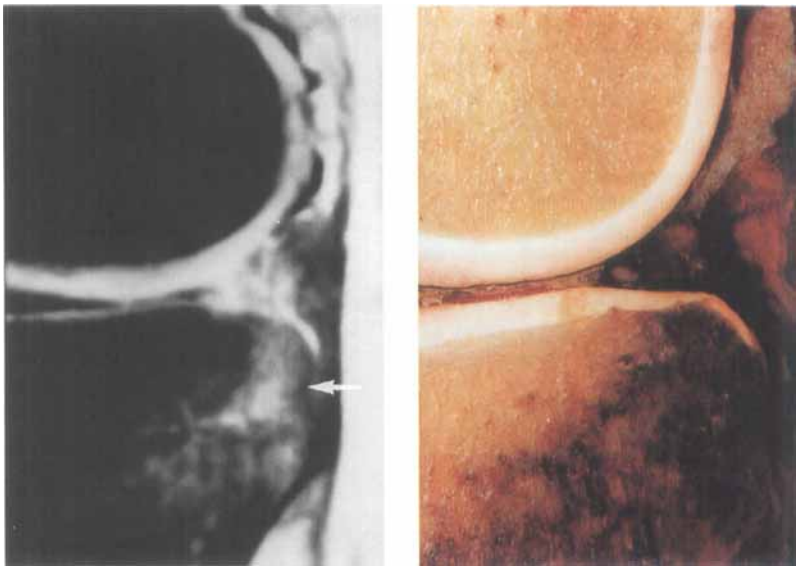

Figure 3. MR imaging (fat-saturated T2*; left) of a bone bruise located posteriorly in the medial tibial plateau of a postmortem specimen (arrow). Corresponding cryotomy slice documents the bone bruise injury (right).

articular surface at arthroscopy. In contrast to the definition by Deutsch et al. (1990), histologic evaluation revealed fragments of hyaline cartilage between intact lamellar trabecules of the subchondral bone indicating involvement of deeper layers of articular cartilage in such injuries (Thompson et al. 1991, Vener et al. 1992).

The mechanism of injury in bone bruises has been discussed. In Mink and Deutsch (1989), 7 of 30 bruises occurred in patients after a direct trauma to the femur or fibula. All had stable knees at clinical examination. Vellet et al. (1991) found that rotation of the tibia and femur relative to each other, as well as deceleration, and valgus force had occurred in two thirds of 83 patients with bone bruise injuries. Others think that the lesion is caused by traumas and forces similar to those which cause an anterior cruciate ligament rupture (Murphy et al. 1992, Stallenberg et al. 1993, Stein et al. 1995, Zeiss et al. 1995). During anterior translation, the posterior aspect of the lateral tibial plateau impinges on the lateral femoral condyle or else a violent reduction of a pivot-shift event might occur. It has been suggested that, with the knee less flexed, the osseous contusion appears more anteriorly on the lateral femoral condyle, and moves posteriorly with increased flexion (Murphy et al. 1992, Stein et al. 1995). In our study, we could not determine the mechanism of injury.

Rotationcryotomy allows removal of sections from the surface of a specimen block with a thickness of 0.1–5 mm in any desired plane. In contrast to rapid freezing at much lower temperatures, this gentle freezing technique prevents the formation of cracks in tissue and disruption of cavities filled with fluid. Excellent correlation between cryosections and previous sonographic, MRI and CT images has been found (Kathrein et al. 1996).

References

Deutsch A L, Mink J H, Shellock F G. Magnetic resonance imaging of injuries to bone and articular cartilage. Orthop Rev 1990; 19: 66-75.

Escalas F, Curell R. Occult posttraumatic bone injury. Knee-Surg-Sports-Traumatol-Arthrosc 1994; 2: 147-9.

Kathrein A, Klestil T, Birbamer G, Buchberger W, Rabl W, Künzel K H. Rotationcryotomy - medical and scientific value of a new serial sectioning procedure. Clin Anat 1996; 9: 227-31.

Kier R, McCarthy S, Dietz M J, Rudicel S. MR appearance of painful conditions of the ankle. Radiographics 1991; 11: 401-14.

Laorr A, Greenspan A, Anderson M W, Moehring H D, McKinley T. Traumatic hip dislocation: early MRI findings. Skeletal Radiol 1995; 24: 239-45.

Mink J H, Deutsch A L. Occult cartilage and bone injuries of the knee: Detection, classification, and assessment with MR imaging. Radiology 1989; 170: 823-9.

Murphy B J, Smith R L, Uribe J W, Janecki C J, Hechtman K S, Mangasarian R A.Bone signal abnormalities in the posterolateral tibia and lateral femoral condyle in complete tears of the anterior cruciate ligament: A specific sign? Radiology 1992; 182: 221-4.

Rangger C, Klestil T, Kathrein A, Inderster A, Hamid L. Influence of magnetic resonance imaging on indications for arthroscopy of the knee. Clin Orthop 1996; 330: 133-42.

Shih C, Chang C Y, Penn I W, Tiu C M, Chang T, Wu J J. Chronically stressed wrists in adolescent gymnasts: MR imaging appearance. Radiology 1995; 195: 855-9.

Soudry G, Mannting F. Hot calcaneus on three-phase bone scan due to bone bruise. Clin Nucl Med 1995; 20: 832-4.

Stallenberg B, Gevenois P A, Sintzoff S A, Matos C, Andrianne Y, Struyven J. Fracture of posterior aspect of the lateral tibial plateau: Radiographic sign of anterior cruciate ligament tear. Radiology 1993; 187: 821-5.

Stein L N, Fischer D A, Fritts H M, Quick D C. Occult osseous lesions associated with anterior cruciate ligament tears. Clin Orthop 1995; 313: 187-93.

Thompson R C, Oegema T R, Lewis J L, Wallace L. Osteoarthritic changes after acute transarticular load. J. Bone and Joint Surg (Am) 1991; 73-A: 990-1001.

Vellet A D, Marks P H, Fowler P J, Munro T G. Occult posttraumatic osteochondral lesions of the knee: Prevalence, classification, and short-term sequelae, evaluated with MR imaging. Radiology 1991; 178: 271-6.

Vener M J, Thompson R C, Lewis J L, Oegema T R. Subchondral damage after acute transarticular loading: An in vitro model of joint injury. J Orthop Res 1992; 10: 759-65.

Zeiss J, Paley K, Murray K, Saddemi S R. Comparison of bone contusion seen by MRI in partial and complete tears of anterior cruciate ligament. J Comput Assist Tomogr 1995; 19: 773-6.