

# Bone bruises: definition, classification and significance

*The increasing use of magnetic resonance imaging in the diagnosis of musculoskeletal injuries has alerted clinicians to the phenomenon of bone bruising. This article will outline the current knowledge and treatment implications of these interesting radiological findings.*

The terms 'bone bruise' or 'bone contusion' are commonly used to refer to areas of localized bony tenderness following trauma, without X-ray evidence of fracture. These painful injuries are sub-periosteal haematomas which can persist for several weeks, but usually resolve spontaneously with no further consequences. However, this is where it gets confusing.

'Bone bruises' are also a group of traumatic bone lesions seen on magnetic resonance imaging (MRI). They are known as 'occult bone lesions' as they are usually not visible on plain radiographs or on direct observation (i.e. at arthroscopy). They are distinct from periosteal haematomas, and should not be confused with these injuries.

This article will review what is known about these interesting MRI findings and explain their importance to sports medicine and orthopaedics.

## Background

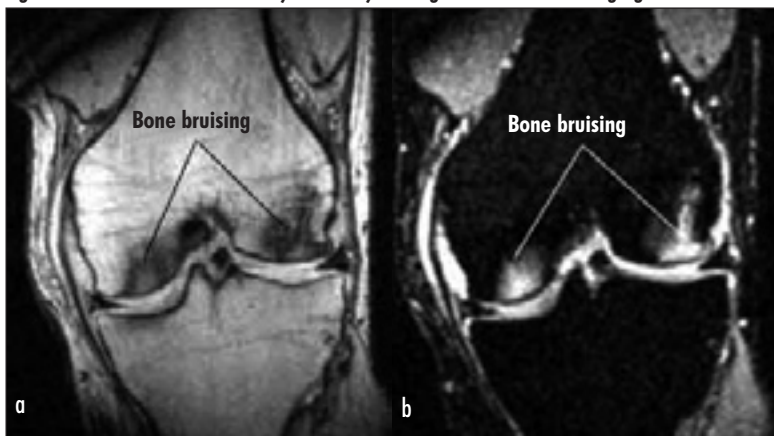
First described by Mink and Deutsch in 1989, MRI bone bruises have only recently been widely recognized. This is mainly a result of the increasing use of MRI in the investigation of acute knee injuries.

MRI shows bone bruises as focal signal abnormalities in the subchondral bone and bone marrow (*Figure 1*). A typical bruise appears as an area of signal loss on T1 images (fluid is black) and high signal intensity on T2 images (fluid is bright), because of the increased water content of the injured area. The best MRI images are produced from short T1 inversion recovery (STIR) sequences, where the signal from normal medullary fat is suppressed and hence bone bruises are highlighted with increased intensity (*Figure 2*).

The appearances are thought to represent micro-trabecular fractures of cancellous (spongy) bone, haemorrhage and oedema of the marrow, without significant

*Figure 2. Short T1 inversion recovery (STIR) image of the right knee showing a small geographical bone bruise in the lateral femoral condyle and an extensive bruise of the lateral tibial plateau in association with an anterior cruciate ligament rupture (kissing contusions).*

**Figure 1. Bone bruises seen on a) T1 and b) T2 magnetic resonance imaging scans.**



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disruption of the adjacent cortices or overlying articular cartilage. In histological biopsies Rangger et al (1998) has found blood and fluid in the region of MRI signal intensity abnormalities, but conclusive evidence of the exact nature of bone bruises is still awaited.

There has been much discussion about the importance of these lesions in predicting the severity and prognosis of injuries, in particular when associated with anterior cruciate ligament (ACL) rupture and the subsequent development of osteoarthritis.

## Classification

There is some debate about the distinction between bone bruises which only involve the subchondral bone, and 'occult fractures', undetected on conventional X-rays, which are similar on MRI but breach the adjacent cortex or articular cartilage interface.

Mink and Deutsch (1989) defined four categories of occult fracture at the knee: bone bruise, stress fracture, femoral and tibial fracture, and osteochondral fracture. A bone bruise was defined as a traumatically involved, geographic and non-linear area of signal loss involving the subcortical bone of the involved bone, with intact overlying articular cartilage.

Vellet et al (1991) modified this classification system, and defined five types of occult fracture: reticular, geographic, linear, impaction and osteochondral, on the basis of their architectural appearance and relationship to cortical bone. Geographic lesions are located close to the cortical margin whereas reticular lesions are entirely contained within the marrow. Impaction fractures show depression of the articular surface usually in association with a geographic lesion, and osteochondral fractures communicate with the joint space.

Although several authors have attempted to improve these classification systems, none have achieved widespread use (Boks et al, 2006). Pooling of data between studies is complicated by the use of different definitions. The terms 'bone bruise' and 'occult subcortical fracture' are applied in the rest of this article as they are used in each individual paper.

## How common are they?

Most of the information regarding the incidence and prevalence of bone bruises comes from studies involving the knee, and in particular following ACL tear.

Vellet et al's (1991) study of 120 consecutive patients presenting with acute traumatic haemarthrosis of the knee identified occult subcortical fractures in 72% of patients (86 of 120). Additionally bone bruises are seen in approximately 80% of patients with an acute ACL injury (Mink and Deutsch, 1989; Spindler et al, 1993). Considering that worldwide it is estimated that more than 250 000 ACL injuries occur per annum, this is a significant number. The phenomenon is also seen in conjunction with meniscal, posterior cruciate and collateral ligament injuries of the knee.

Labovitz and Schweitzer (1998), in a retrospective review of 109 MRIs taken post-ankle sprain, identified bone bruises in 39% of patients. Furthermore multiple bone bruises were seen in 40% of those with bruises and they occurred more frequently in patients with multiple ligaments injured. Other anatomical sites where bone bruises have been identified include the hip, elbow, foot and spine. As they can only be detected on expensive MRI scanning, it is likely that most go unrecognized.

Although occult bone lesions may occur wherever there is external trauma to bone, most knee and ankle sprains occur from forceful twisting injuries. It is thought that the bruises are caused as adjacent bones are forcefully impacted (kissing contusions). In ACL tears bone bruises are mainly seen in the lateral tibial plateau and femoral condyle, which is consistent with the valgus mechanism of injury.

The reasons why some people with the same injury get bone bruises and others do not can be explained by the inherent variation in exact mechanism and force of each individual injury.

## How long do they take to heal?

Boks et al (2006) have published a systematic review of the current literature regarding the natural history of occult bone lesions. They identified 266 articles but only included 13 as quality studies. The percentage of complete resolution of bone bruises on magnetic resonance scanning ranged from 88% after 11–16 months of follow up to 100% after 2 or 5–12 months of follow up. Comparison between studies was hindered by different outcome measures and varying lengths of both clinical and MRI follow up.

Time to resolution will clearly depend on the severity of the initial injury and possibly the level of activity in the healing phase.

As bone bruising in the knee is so often associated with ligamentous and meniscal damage, it is difficult to attribute clinical symptoms to bruising alone. For this reason MRI is the best way of demonstrating healing.

## Do bone bruises cause osteoarthritis?

Osteoarthritis is a recognized complication of conservatively treated ACL tears. It is generally thought that the global instability of the ACL-deficient knee predisposes to 'wear and tear' of the joint surface.

However, this does not explain why the incidence of radiographic osteoarthritis found in reconstructed knees has been found to be equal to, or even greater than, those conservatively treated (Friederich and O'Brien, 1993; Daniel et al, 1994).

The fact that bone bruises are commonly found in ACL injuries has raised the possibility that they may either be a prognostic indicator or a direct cause of degenerative changes.

In the review by Boks et al (2006) all cases of reticular bruising (confined to the bone marrow) showed full

resolution with no osteochondral sequelae at follow-up magnetic resonance scanning. Conversely cartilage loss was detected in all cases of initial cortical impaction and osteochondral fracture. Geographic lesions have a varying prognosis. Vellet et al (1991) found that 78% of patients (14 of 18) with a geographic lesion had evidence of degenerative cartilage changes adjacent to the site of the initial lesion at follow-up scanning. This contrasts with the findings of Costa-Paz et al (2001) who found evidence of only one of 11 geographic lesions present after 24–64 months. This difference could be accounted for by the much longer follow-up period used compared with Vellet's study, during which time further healing was possible.

Lahm et al (2004), using a well-validated canine model, showed that pure subchondral bone damage leads to cartilage degeneration after 6 months on both MRI and histology sections. In this study 12 dogs had a standardized transarticular force applied across their right knee joint, of sufficient magnitude to produce subchondral fracture without any evidence of cartilage damage on initial MRI scanning. The non-impacted left knee was used as a control in every animal. Six months after trauma a second MRI was performed and osteochondral sections were taken from both the area above the former subchondral lesion and the corresponding area of the unaffected knee joint. On follow up, MRI and histology showed articular cartilage changes in 10 of the 12 knees with former subchondral injury.

There are two main theories explaining how occult osseous lesions that do not disrupt the joint surface may lead to osteoarthritis.

Animal studies have shown that impactive cartilage loading, which causes cartilage changes consistent with osteoarthritis, also produces evidence of subcortical microtrabecular fractures (Radin et al, 1973). This suggests that the presence of subchondral bone bruises may indicate a significant, unseen injury to the articular cartilage caused by the initial traumatic event. In this way bone bruises may serve as a prognostic indicator for future cartilage deterioration, without being directly involved in the disease process.

An alternative hypothesis is that once subchondral microfractures heal, they leave a stiffer construction than

the previously normal spongy bone. The decreased compliance might then generate greater mechanical loads on the overlying articular cartilage, leading to progressive degeneration (Rosen et al, 1991).

### Future directions and treatment implications

Bone bruises have been most well characterized in the knee, but an element of this can be explained by the number of MRI scans performed in that area. As MRI gains popularity in the evaluation of other injuries it is likely that more associations will appear. These lesions may provide an explanation for ongoing pain in clinically intact limbs and also reduce the indications for diagnostic arthroscopy in the place of MRI scanning. In addition they may provide a potential target for therapeutic agents aimed at preventing the development of osteoarthritis following ACL and other injuries.

Johnson et al (2000) have shown that severe geographic bone bruising following injury is associated with increased disability including prolonged knee effusion, pain and increased time to achieve normal range of motion of the joint. When combined with ACL or other ligamentous and meniscal pathology, this may affect the time to operation and postoperative rehabilitation.

Post-ACL reconstruction the presence of bone bruises may require modifications to rehabilitation regimens, such as open kinetic chain in isokinetic treatment, as some studies have shown high axial forces in closed kinetic chain rehabilitation programmes.

If not adequately protected during trabecular healing, bone bruises may represent regions of bone theoretically at risk for the subsequent development of insufficiency fractures or osteochondral sequelae. For injuries in the lower extremity, some authors advocate a delay before resuming full weight bearing and resumption of sports activities, both for the alleviation of pain and to lessen the risk of potential progression of these regions of trabecular disruption into complete fractures.

There is clearly the need for further studies involving both long-term clinical and magnetic resonance follow-up to clarify the natural history of bone bruises. Their high association with ACL injuries makes this cohort of patients a good model for this purpose.

When they were originally described by Mink and Deutsch (1989) bone bruises were thought to be a purely benign abnormality. Early follow-up studies showed both clinical and magnetic resonance resolution without any evidence of a progressive abnormality. Most of these studies, however, included non-consecutive patients and had a non-structural follow-up or concerned only case reports. It now seems probable that certain types of bone bruise are associated with changes in subchondral bone which may contribute to the early degeneration of articular cartilage, and the subsequent development of osteoarthritis.

### KEY POINTS

- Bone bruises are a heterogenous group of occult traumatic bone lesions seen on magnetic resonance imaging as signal intensity abnormalities in the subchondral bone and bone marrow.
- They are thought to represent microtrabecular fractures of cancellous bone, haemorrhage and oedema of the marrow.
- As well as causing pain and delaying recovery from injuries, certain types of bone bruises may lead to osteoarthritic changes.

The term 'bone bruise' itself is non-specific and should be used with caution. In order to avoid confusion clinicians should make it clear whether they are referring to periosteal injuries or MRI findings. In addition the term should not be used to describe all types of occult bone lesion detected on MRI, but remain reserved for pure subcortical injuries, as in Mink and Deutsch's original classification. **BJHM**

*Conflict of interest: none.*

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