Magnetic Resonance in Acute Knee Trauma: Correlation of Bone Bruise Location and Rupture of Anterior Cruciate Ligament

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Learning objectives

The aim of this paper is to present the most frequent distribution of bone bruises in patients where physical examination raised the suspicion, and MR examination diagnosed complete tear of anterior cruciate ligament following acute knee trauma.

The distribution of bone bruises may suggest the injury mechanism and can be useful secondary sign in determining of type of ligamentous injury.

Background

Magnetic resonance is modality of choice in imaging of the knee joint after trauma since it is superior to other imaging modalities like plain radiography, CT and ultrasound in revealing of bone and soft tissue lesions (1).

Posttraumatic bone contusions are common in the knee (2).

Bone bruise as term is used as a synonym for areas of contused cancellous bone with high signal intensity in MR fat suppression sequences. These lesions represent spectrum of occult bone lesions like bleeding, bone infarction, edema or microscopic compression fractures of the bone without disruption of compact cortical bone continuity (1).

Magnetic resonance is the only diagnostic modality that can display bone bruises.

Bone bruises may appear isolated or may be associated with other soft tissue injuries of the knee (3).

Bone bruises have low signal intensity in T1, and high signal intensity in T2 and fat suppressed sequences (Fig. 1 on page 4, Fig. 2 on page 5).

Bone bruises are important mainly because they are responsible for pain symptoms in patients. They may lead to osteochondral defects and consequent early degenerative disease of the knee joint (3).

Precise location of bone bruise can suggest injury mechanism and can direct the search to the knee structures that have to be thoroughly analyzed with magnetic resonance. A bone bruise is like a footprint left behind the injury. By analyzing the distribution of bone bruises one can with accuracy assume the injury mechanism and predict associated soft tissues injuries that can be expected (4).
Majority of bone bruises occur in lateral compartment of the knee and they are associated with anterior cruciate ligament (ACL) tears, lateral patellar dislocations and medial collateral ligament tears (2).

Bone bruises are most frequent in acute rupture of anterior cruciate ligament (ACL) and are typically located in the central part of lateral femoral condyle and the posterolateral tibial plateau (3) (Fig. 3 on page 6, Fig. 4 on page 7, Fig. 5 on page 8, Fig. 6 on page 9).

Contusions of medial compartment at acute rupture of ACL are not common and some authors suggest that this type of injury occur as the consequence of avulsion at the semimebranosus attachment or contrecoup impaction during knee rotation (5) (Fig. 7 on page 10).

Anterior cruciate ligament is main stabilizer of the knee and the most frequently injured ligament in human organism (6,7,8).

Anterior cruciate ligament stabilizes the knee joint by preventing anterior dislocation and medial rotation of tibia with respect to the femur (7).

Therefore early and correct diagnosis of anterior cruciate ligament lesion is important (7).

Knowledge of anatomy of anterior cruciate ligament (ACL) is crucial for detection of the injury (7).

Anterior cruciate ligament attaches to dorsal medial facet of lateral condyle of the femur and has caudal attachment on tibia in anterior intercondylar area, a bit laterally and anterior to anterior tibial spine. While knee is extended ACL has the length of approximately 32 mm, and width of 7-12 mm. ACL and posterior cruciate ligament (PCL) are completely covered with synovial, and is extrasynovial but intraarticular. It consists of anteromedial and posterolateral bundles (6).

Normally ACL has low signal in all sequences. In MR imaging of ACL sagital images are readily used. However ligament is displayed better by use of oblique sagital images which are obtained by lateral rotation of the knee for 10-15°. On oblique sagital spin echo images ACL is well defined low signal intensity structure that extends parallel with roof of intercondylar notch (7).

The most frequent site of ACL injuries is in central part (90%), followed with injury at femoral attachment (9%), and with the least frequent site of ACL injury at tibial attachment (3%) (7).

The most frequent ACL injury mechanism represents anterior dislocation of tibia in respect to the femur which results in impaction of lateral condyle on posterolateral part of tibial plateau, where subsequent bone bruises are most likely to occur. Accurate location
of bone bruises depend on the level of knee flexion at the moment of injury. If the degree of flexion in the knee is high contusions on lateral condyle of the femur will be located in posterior parts of the bones, and in opposite if the degree of flexion in the knee joint at the moment of the injury is low, the bone contusion will be located in anterior parts of femur and tibia (4).

Magnetic resonance is useful tool in imaging of complete anterior cruciate ligament tear. Sensitivity and specificity of MR in imaging of complete ACL tear is 92-96%, and 89-98%, respectively. Primary and secondary signs are used for diagnosis of complete ACL tear (6).

Primary signs are based on shape and signal intensity of ACL at MR images and include discontinuity of ligament with high signal in T2 and fat suppression sequences, as well as complete absence of the ligament (6, 9) (Fig. 8 on page 11).

Secondary signs of ACL tear are: joint effusion, bone bruise situated at lateral compartment, anterior translation of tibia, meniscal tear, and tear of the medial collateral ligament (6, 9, 10).

Images for this section:
Fig. 1: T1 W cor. "bone bruise" lateral femoral condyle (arrow)
Fig. 2: PD FS cor. "bone bruise" lateral femoral condyle (white arrow) and MCL tear (red arrow)
Fig. 3: PD FS sag. "bone bruise" in central portion of lateral femoral condyle and in posterolateral portion of tibial plateau (arrow)
Fig. 4: PD FS cor, "bone bruise" in lateral femoral condyle and in posterolateral portion of tibial plateau (arrow)
Fig. 5: PD FS cor, "bone bruise" in posterolateral portion of tibia (arrow)
Fig. 6: PD FS tra, "bone bruise" in central portion of lateral femoral condyle (arrow)
Fig. 7: PD FS cor, "bone bruise" in tibia posterolateral and posteromedial (arrow)
**Fig. 8:** PD FS sag. Complete ACL tear (arrow)
In this study we have analyzed presence, frequency and location of bone bruises at patients with clinical suspicion, and MR verification of complete ACL tear following acute trauma.

Study included 30 patients with MR signs of complete ACL rupture following acute trauma. Patients were examined from June 2010 to June 2011. MR examinations were performed on 1.5 T MR scanner (Siemens "Avanto") and 3 T MR scanner (Siemens "Trio Tim").

We used knee high resolution TX/RX coil. Examination was conducted with use of knee MR protocol with FOV-160:

- T1 TSE tra, cor (slice thickness 3 mm);
- T2 TSE tra, sag (slice thickness 3 mm);
- PD TSE FS tra, cor, sag (slice thickness 3 mm);
- T2 DE3D sag (slice thickness 0.5 mm);
- T2* (FL 2D tra) (slice thickness 3 mm);
- T2 TIRM cor (slice thickness 3 mm);

The mean age of the patients was 27.5 years (16-42) with male to female ratio 5:1.

Result of our study have shown the existence of bone bruises at posterior lateral part of tibial plateau in 22 patients (73.3%), followed by those in central part of femoral lateral condyle found in 21 patient (70.0%), and medial condyle in 3 patients (10.0%).

As additional findings we have diagnosed lesion of medial meniscus in 4 patients, lesion of lateral meniscus in 1 patient, and complete tear of medial collateral ligament in one patient as well (Table 1).

<table>
<thead>
<tr>
<th>Total number of patients</th>
<th>Bone bruise-lateral femoral condyle</th>
<th>Bone bruise-posterolateral tibial plateau</th>
<th>Bone bruise-medial femoral condyle</th>
</tr>
</thead>
<tbody>
<tr>
<td>30</td>
<td>21</td>
<td>22</td>
<td>4</td>
</tr>
<tr>
<td>100%</td>
<td>70.0%</td>
<td>73.3%</td>
<td>10.0%</td>
</tr>
</tbody>
</table>

Table 1. Distribution of bone bruises (numerical and percentage representation)

Conclusion
Results of our study have shown that in the case of complete ACL tear the most frequent location of bone bruise is central portion of lateral femoral condyle and posterolateral tibial plateau. This result can be used as a useful secondary sign in diagnosis of complete ACL tear.

The location of bone bruises in lateral femoral condyle and posterolateral part of tibial plateau can suggest the presence of complete rupture of ACL, and should be carefully analyzed radiologically and clinically.

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**References**


