Bone Contusions of the Posterior Lip of the Medial Tibial Plateau (Contrecoup Injury) and Associated Internal Derangements of the Knee at MR Imaging

PURPOSE: To determine if there are any predictable patterns of internal derangement associated with a bone contusion of the posterior lip of the medial tibial plateau at magnetic resonance (MR) imaging and to offer a biomechanical explanation for the findings.

MATERIALS AND METHODS: A retrospective review of 215 consecutive MR examinations for knee trauma was conducted to identify contusions of the posterior lip of the medial tibial plateau. Any additional contusions and internal derangements were documented in the cases with these contusions. Medical charts and arthroscopic results, when available, were reviewed for mechanisms of injury.

RESULTS: The specific medial tibial contusion was demonstrated in 25 of 215 (12%) knee MR examinations. Associated anterior cruciate ligament (ACL) tears were found in 25 of the 25 (100%) examinations. Injury to the meniscocapsular junction (14 of 25) or a peripheral tear of the posterior horn of the medial meniscus (10 of 25) occurred in a combined 96% of the cases. Lateral compartment contusions were noted in 24 (96%) cases. Pivot, twisting, or valgus forces were reported mechanisms of injury.

CONCLUSION: Contusions involving the posterior lip of the medial tibial plateau may result from a contrecoup impaction injury directly following an ACL tear, as the knee reduces. These contusions are almost always associated with a far peripheral meniscal tear or with a meniscocapsular junction injury affecting the posterior horn of the medial meniscus.
MATERIALS AND METHODS

One musculoskeletal radiologist (P.A.K.) retrospectively reviewed 215 consecutive MR studies that were obtained for knee trauma and/or injury, looking specifically for a bone contusion on the posterior lip of the medial tibial plateau. All MR examinations were performed by using a 1.5-T MR unit (Siemens, Erlangen, Germany). Imaging planes and pulse sequences consisted of the following: sagittal T1-weighted (600/20 [repetition time msec/echo time msec]) sequence; sagittal and axial gradient-echo (two-dimensional, fast low-angle shot, 770/18, 30° flip angle) sequences; and coronal selective water excitation double-echo steady state (WE DESS, Siemens) (26.8/9) sequence. The WE DESS sequence is a combination of a heavily T2-weighted sequence and a gradient-echo sequence that is designed to show fluid with great sensitivity.

A coronal turbo short inversion time inversion-recovery (STIR) (5,500/29/150 [repetition time msec/echo time msec/inversion time msec]) sequence was used in place of the WE DESS sequence in the last 26 cases evaluated. The strength of the STIR sequence is its contrast resolution and, therefore, its ability to demonstrate fluid.

All knees were imaged with an extremity coil by using a 4-mm section thickness with a 10% gap, a 14-cm field of view, and one signal acquired. The matrix was 384 × 512.

MR studies in patients with a contusion of the posterior lip of the medial tibial plateau were then evaluated by consensus by three musculoskeletal radiologists (P.A.K., R.G.D., M.W.A.) for any additional bone contusions, meniscal tears, abnormal signal intensity at the meniscocapsular junction, cruciate and collateral ligament injuries, or other anatomic disruptions of the knee, using accepted criteria (14). The time elapsed from the time of injury to the time of MR examination was documented in patients with the medial tibial contusion.

Clinical data from patient charts were reviewed by an orthopedic surgeon (D.R.D.) in those who had the medial tibial contusion to document the forces and the position of the knee at the time of injury to help determine the mechanism of injury. These data included information such as the athletic activity, the position of the knee at the time of injury, and the direction of the blow to the knee. Arthroscopic results available in patients with contusion of the posterior lip of the medial tibial plateau were reviewed (D.R.D., P.A.K.).

RESULTS

Of the 215 knee MR studies reviewed, 25 (12%) showed a contusion of the posterior lip of the medial tibial plateau. There were 20 male and five female patients with the tibial contusions; their ages ranged from 16 to 52 years (mean age, 28 years). All MR examinations were performed within 4 weeks of the knee injury.

MR Findings in Patients with a Medial Tibial Plateau Contusion

Bone contusions.—Each of the 25 contusions of the medial tibial plateau was located on the posterior margin or lip of the tibia in the subchondral portion of bone (Fig 1). Bone contusions were defined as geographic regions of abnormal signal intensity—low signal intensity on T1-weighted images and high signal intensity on STIR, WE DESS, or gradient-echo images—abutting the subchondral cortical bone. The margins of the contusion protruded into the marrow with a convex configuration. In the axial plane, if the tibial plateau is viewed as the face of a clock, this contusion was predictably located in approximately the 5- or 7-o'clock position for the right and left knees, respectively (Fig 2a). No osteochondral or impaction fracture was seen in relation to these medial contusions.

Lateral compartment bone contusions were evident in 24 of 25 patients (Fig 3a). These were the typical contusions involving the weight-bearing surface of the lateral femoral condyle and the posterior aspect of the lateral tibial plateau, which are known to be commonly associated with ACL tears (Fig 3b). The patient without lateral compartment bone contusions was one of two patients with a medial meniscal bucket-handle tear. One patient had a radiographically occult fracture of the head of the fibula.

Five knees had a small subchondral bone marrow contusion on the far medial peripheral surface of the lateral femoral condyle, just posterior to the medial collateral ligament (Fig 2b); this contusion was always more posterior than was the contusion involving the lateral femoral condyle (Fig 2c). All medial compartment contusions were smaller than the corresponding lateral compartment contusions (Fig 2d).

Ligaments and tendons.—All patients with a medial tibial plateau bone contusion had tears of the ACL. There was high signal intensity along the path of the disrupted ACL from hemorrhage and/or edema, which indicated these were acute.

Figure 1. Sagittal T1-weighted MR images (600/20) from two knees show typical (a) small and (b) large bone contusions (arrows) with different configurations of the posterior lip of the medial tibial plateau.
injuries. Two knees showed partial tears of the medial collateral ligament. Two other knees had tears of the posterior portion of the medial patellar retinaculum immediately anterior to the medial collateral ligament. High signal intensity within the semimembranos tendon compatible with a partial tear was evident on MR images for four of 25 knees.

Menisci.—Medial meniscal tears were identified in 16 of 25 (64%) patients with a medial tibial contusion involving the posterior horn; 10 (62%) of these patients had medial meniscal tears that involved the far peripheral 20% of the posterior horn near the attachment of the meniscus to the joint capsule (Fig 4). Two of the 16 medial meniscal tears were bucket-handle tears, with meniscal tissue displaced into the intercondylar notch.

Abnormal signal intensity on gradient-echo, WE DESS, or STIR images was seen between the meniscus and the joint capsule, which indicated hemorrhage and edema from an injury to the meniscocapsular junction or from meniscocapsular separation, in 14 of 25 (56%) knees (Fig 5). Only the posterior horn of the medial meniscus was involved with abnormal signal intensity at the meniscocapsular junction. These 14 meniscocapsular junction injuries could sometimes be seen in both coronal and sagittal planes (n = 7), but in other cases they could be detected in only the sagittal (n = 3) or only the coronal (n = 4) planes but not in both. Four patients with a meniscocapsular injury had a coexistent medial meniscal tear, although none of these tears were far peripheral in the meniscus; five patients had a coexistent lateral meniscal tear.

Lateral meniscal tears were present at MR imaging in nine of 25 patients with a medial tibial plateau contusion. There were four vertical peripheral tears, two radial tears, and three complex tears of the lateral meniscus, evenly distributed between the anterior and posterior horns.

Chart Review

All but two patients were injured during athletic activities that included basketball (n = 11), soccer (n = 4), football (n = 3), skiing (n = 2), lacrosse (n = 2), and softball (n = 1). The nonathletic injuries involved considerable trauma to the lateral side of the knee caused by a car hitting a pedestrian in one case and by someone sliding down a bannister into the victim’s knee in the other instance. The mechanisms of injury in all cases were pivot, twisting, or valgus forces that predisposed the knee to ACL tears. Marked flexion of the knee was not present in any of the patients at the time of injury.

Arthroscopic Findings

Twelve of 25 patients with a contusion of the posterior lip of the medial tibial plateau had undergone arthroscopy. Three arthroscopic procedures were performed within 3 weeks of the injury; nine procedures were performed between 8 and 12 weeks after the injury.

Complete ACL tears were found in all of these patients. MR images were interpreted as showing far peripheral tears of the posterior horn of the medial meniscus near the meniscocapsular junction in five patients who underwent arthroscopy, and the finding was corroborated in four (80%) patients. Abnormal signal intensity at the meniscocapsular junction, believed to indicate either contusion or meniscocapsular separation, was seen in seven of 12 (58%) patients who underwent arthroscopy, and the injury was confirmed in three of the seven (43%) individuals.

Other data regarding arthroscopic findings will not be delineated since the correlation between MR imaging and arthroscopy has been well proved in the literature, and other abnormalities found in this study are not specifically relevant to the medial tibial contusion.

DISCUSSION

Findings of this investigation demonstrated that a small contusion of the posterior lip of the medial tibial plateau,
which was identified in 25 of 215 consecutive MR examinations performed for knee trauma, occurred in association with MR imaging findings of a torn ACL in all cases and either an injury to the meniscocapsular junction (n = 14) or a tear of the outer periphery of the posterior horn of the medial meniscus (n = 10) in 96% of the patients. Other bone contusions were also common and usually involved the lateral compartment of the knee (24 of 25 patients), but a second medial compartment contusion affecting the medial margin of the medial femoral condyle, just posterior to the medial collateral ligament, was seen in five knees.

Bone contusions in the knee have often been used as secondary signs for detecting other associated abnormalities and as a means of increasing confidence in the diagnosis (1–11). The classic example is the lateral compartment contusion of the posterior aspect of the lateral tibial plateau and of the midlateral femoral condyle just above the anterior horn of the lateral meniscus, which is associated with ACL tears (Fig 2). However, relying on secondary signs such as lateral compartment bone contusions to diagnose an ACL tear is generally unnecessary and could lead to an inaccurate diagnosis (15). The reasons for the last statement are that the ACL tear is easily, accurately, and directly identified at MR imaging, and ligamentous laxity allows for the contusions to occur without disruption of the ACL in 28% of patients 20 years old or younger (15).

The real value in recognizing lateral compartment contusions is they may be a source of pain; they may lead to osteochondral defects and early degenerative joint disease, if severe; and they are a reflection of the biomechanics of the injury. These same points apply to bone contusions elsewhere in the knee or in other joints in the body. Recognizing the mechanism of injury and analyzing the biomechanics can help lead to a more systematic and focused evaluation of an injured joint. Bone contusions reveal part of what took place at the time of the injury and may lead to more careful scrutiny of other structures that are possibly injured. Bone contusions may be more easily recognized than are the abnormalities with which they are associated. This is the case with medial compartment bone contusions in the knee, which are far more conspicuous than most of the associated meniscal or meniscocapsular abnormalities.

We propose that the bone contusion of the posterior lip of the medial tibial plateau and the occasionally evident associated contusion of the medial femoral condyle most likely occur as a contrecoup injury as the tibia reduces following an ACL rupture (Fig 6). While there are val-
in its rupture. As the ACL ruptures, the posterior aspect of the lateral tibial plateau impacts the midpoint of the articular surface of the lateral femoral condyle (this is the initial, or coup, portion of the injury), creating the familiar lateral compartment contusions.

The medial compartment contusions described in this article are in nearly the same locations as are the lateral contusions, but they are on the medial side of the knee. The medial contusion occurs as a contrecoup injury after the impact on the lateral side. The medial aspects of the tibia and femur impact against one another when the knee is reducing and go into a compensatory varus alignment, with the femur rotated internally and with the tibia remaining displaced anterior to the femur.

Dissipation of forces occurs after the initial impact of the bones in the lateral compartment, which explains why the medial contusions are considerably smaller and less commonly encountered than are those on the lateral side. Only injuries with large forces could result in medial bone contusions, which was the case with the young patients and with the sports-related trauma that led to the injuries in all but two of the cases in this investigation. The contusion of the medial femoral condyle is more posterior than is the lateral femoral condyle contusion, and this can also be explained by dissipation of forces since there would be less internal than initial external rotation of the femur, and because the amount of anterior tibial subluxation would be decreased.

The knee with medial, but not lateral, compartment contusions can probably be explained by a slightly different mechanism of injury, with major varus rather than valgus forces applied at the time of injury. This was one of only two knees with a bucket-handle tear of the medial meniscus, which indicates sizable compressive forces directed medially rather than laterally.

The subchondral contusion involving the peripheral margin of the medial femoral condyle is almost certainly more common than these study findings suggest. All but one of the medial femoral condyle contusions were seen in the few cases in which we used the STIR sequence. Although the WE DESS sequence used for the coronal images in most patients was designed to show fluid, it was clear that the STIR sequence was far more sensitive to the presence of fluid in marrow. Our protocol for the sagittal imaging plane consists of T1-weighted and gradient-

---

**Figure 5.** Sagittal (a) T1-weighted (600/20) and (b) gradient-echo (770/18, 30° flip angle) MR images of arthroscopically proved meniscocapsular separations of the posterior horn of the medial meniscus that are common in patients with medial tibial bone contusions. Note the fluid (arrow) interposed abnormally between the meniscus and the capsule.

**Figure 6.** Diagram of the mechanism for developing bone contusions at the time of ACL rupture. Outlines of the distal femur (thin line) and of the proximal tibia (thick line) are superimposed A before; B, C during; and D after injury. A, Knee in normal position, without contusions. MCL = medial collateral ligament. B, Knee in valgus alignment after initial blow, or coup. The tibia (thick line) subluxates forward on the externally rotated femur (thin line), and lateral compartment contusions (lined areas in B–D) occur as the ACL ruptures and as the bones impact against one another. C, Contrecoup injury occurs medially, after dissipation of forces when there is compensatory varus alignment with internal rotation of the femur and persistent (although decreased) anterior subluxation of the tibia, which allows impact with bone contusions at specific locations in the medial compartment (dotted area). D, Knee is reduced, with normal relationship of the tibia relative to the femur after injury. Lateral (lined area) and medial (dotted areas) compartment bone contusions are shown in their typical locations.
Meniscal tears are found in 40%–70% of patients with acute ACL tears. In our study, of the 25 patients who had the medial tibial plateau contusion, 16 (64%) had a tear of the posterior horn of the medial meniscus, and 10 of the 25 (40%) knees had injuries that involved the peripheral 20% of the posterior horn. In addition, 14 of the 25 (56%) patients with the medial tibial contusion had evidence of a meniscocapsular junction injury.

Yao and Lee (24) previously reported two cases of fracture of the posteromedial corner of the medial tibial plateau. Both cases had associated ACL tears. These fractures were true linear fractures and were believed to be avulsion injuries at the site of attachment of the semimembranosus tendon. In our investigation, four of the 25 patients with medial tibial plateau contusions showed increased signal intensity in the semimembranosus tendon compatible with injury. We believe our cases are different from those published by Yao and Lee (24) because the tibial lesions in our study had no linear fracture component or separate fragments; they all were geographic areas of abnormal signal intensity in the subchondral bone. Undoubtedly, there must be a spectrum of findings possible that depends on the severity of the injury.

In conclusion, we propose that medial compartment bone contusions involving the posterior lip of the medial tibial pla-
and, occasionally, the medial femoral condyle occur as contrecoup impact injury following ACL tears. These bone contusions are almost always associated with far peripheral meniscal tears, meniscocapsular contusions, or separations affecting the posterior horn of the medial meniscus. The meniscal or meniscocapsular injuries generally are much less conspicuous than are the bone contusions and should be carefully searched for when the contusion is seen.

References