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Abnormal lateral notch in knees with anterior cruciate ligament injury

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Abstract: We reviewed plain radiograms of anterior cruciate ligament injuries to determine the frequency of an abnormal lateral notch found in the lateral femoral condyle, and we investigated a possible mechanism for its occurrence by determining the relationship with associated injuries. We analyzed data for 216 patients who underwent ACL reconstruction between 1993 and 1996, whose radiographic images of the contralateral knee were available. The numbers of male and female patients were 122 and 94, respectively, and their ages ranged from 14 to 47 years (average, 25 years). The abnormal notch visualized by lateral radiograph was found in 66 of 216 knees (30.6%) and was classified into three types. The type of abnormal notch seen most frequently (73%) was located at the same site as the notch on the contralateral side, but appeared deeper than normal. Knees with abnormal notches showed lateral meniscal injuries more frequently than those without such notches ($P < 0.005$). The abnormal notch was assumed to have formed at the time of injuries, after impingement of the lateral femoral condyle on the lateral tibial condyle. Cartilage damage at the abnormal notch should be carefully observed in the future.

Key words: abnormal lateral notch, anterior cruciate ligament injury, bone bruise, lateral meniscus injury

Introduction

Reports of anterior cruciate ligament (ACL) injuries[1,19] have stated that, on lateral radiographs, an abnormal notch is sometimes observed in the lateral femoral condyle of knees with ACL injuries (Fig. 1).

In 1977, MacIntosh and Darby[11] first noted an abnormal notch in the lateral femoral condyle, the depth of which ranged from 1 to 2 mm in 32 of 50 knees with a ruptured ACL. Bach et al.[1] defined the notch as being 2 mm or more in depth. Warren et al.[19] reported that ACL injuries were frequently found in knees with an abnormal notch 2 mm or more in depth, and the X-ray findings mimicked those of osteochondral fractures or osteochondritis dissecans. According to Zarins and Rowe,[20] cartilaginous degeneration was found in 10 of 106 knees in which ACL reconstruction had been performed, and Losee and Johnson[9] found abnormal notches in 15 of 37 knees with ACL injuries. Noyes et al.[14] noted a notch defect in the lateral femoral condyle in the ACL-deficient knee and stated that this was probably caused by gross anterolateral subluxation (giving way).

We reviewed the records of our patients with ACL injuries, to determine the frequency of abnormal lateral notches and their relationship with associated ligamentous or meniscal injuries, and to discuss the possible mechanisms by which they occur.

Subjects and methods

Of the 288 knees with ACL injuries on which ACL reconstruction had been performed in our hospital between 1993 and 1996, we reviewed and examined bone bruises, using magnetic resonance imaging (MRI), in the knees of 216 patients in whom radiograms of the injured and the contralateral knees were available. The numbers of male and female patients were 122 and 94, respectively, and their ages ranged from 14 to 47 (average, 25 years). Sports activities during which the injuries were sustained included skiing ($n = 65$), basketball ($n = 40$), American football ($n = 27$), soccer

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($n = 20$), rugby ($n = 20$), volleyball ($n = 13$), and others ($n = 31$).

We defined an abnormal lateral notch as being either deeper than that on the contralateral side, or located at a site different from that of the normal contralateral notch regardless of its depth. The frequency of an abnormal lateral notch, visualized by lateral radiogram, the mechanism of injury (contact or non-contact),

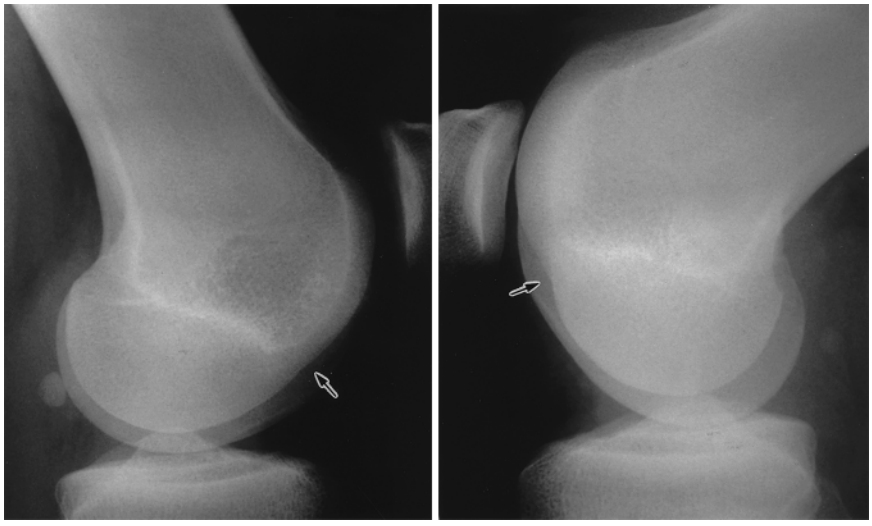

Fig. 1. **a** Normal lateral notch (*arrow*); **b** abnormal lateral notch (*arrow*) in the same patient

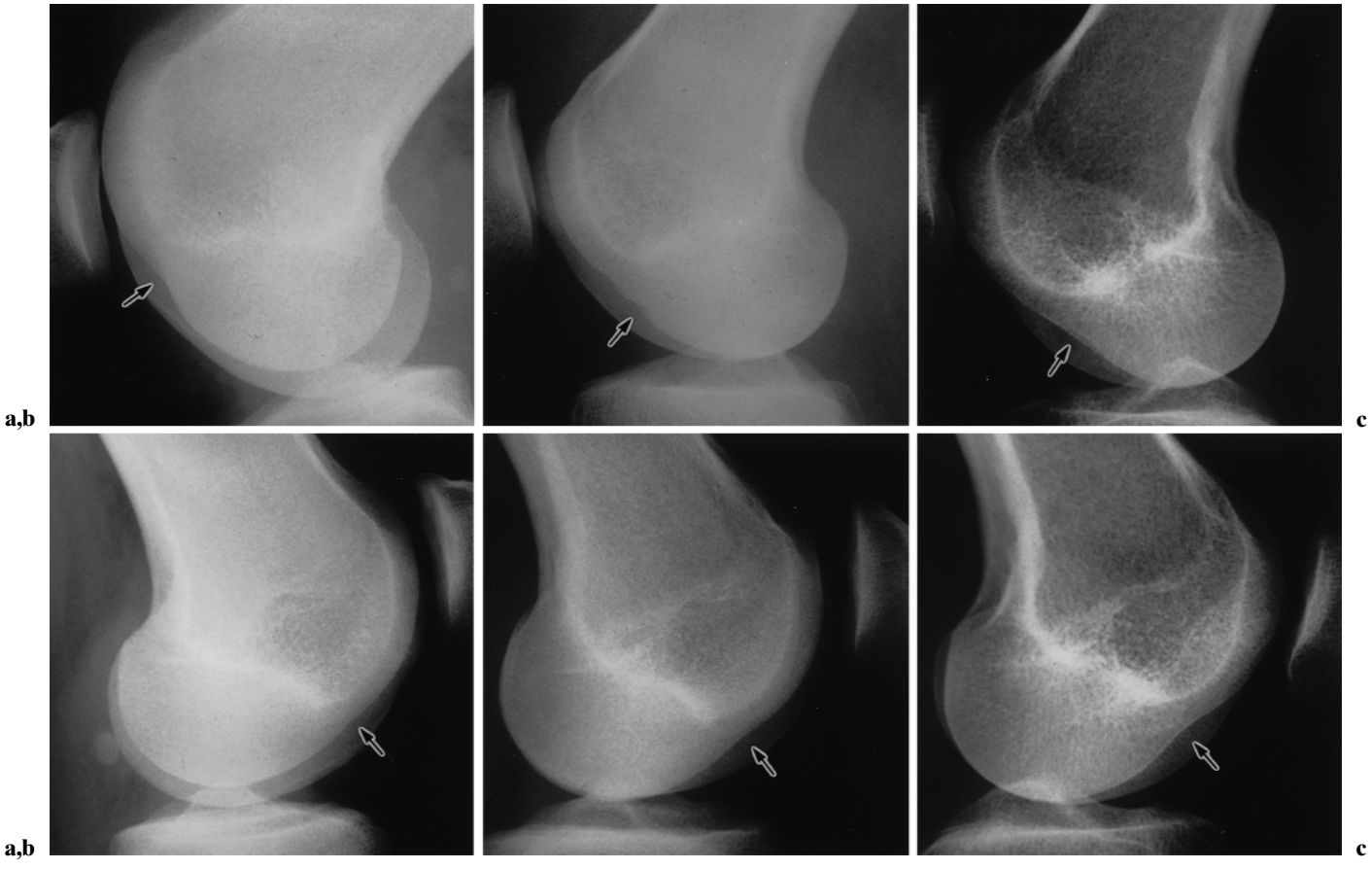

Fig. 2a–c. *Upper* photographs show classification of abnormal notches. **a** Type I; **b** type II-A; **c** type II-B. *Lower* photographs show the contralateral knees in the same patients. See text for explanation of types. *Arrows* show notches

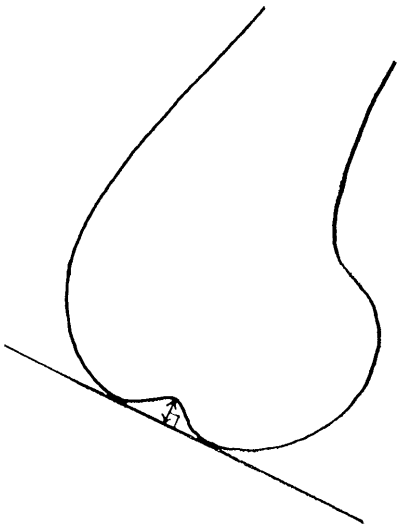

Fig. 3 Method of measurement of depth of the lateral notch. See text for explanation

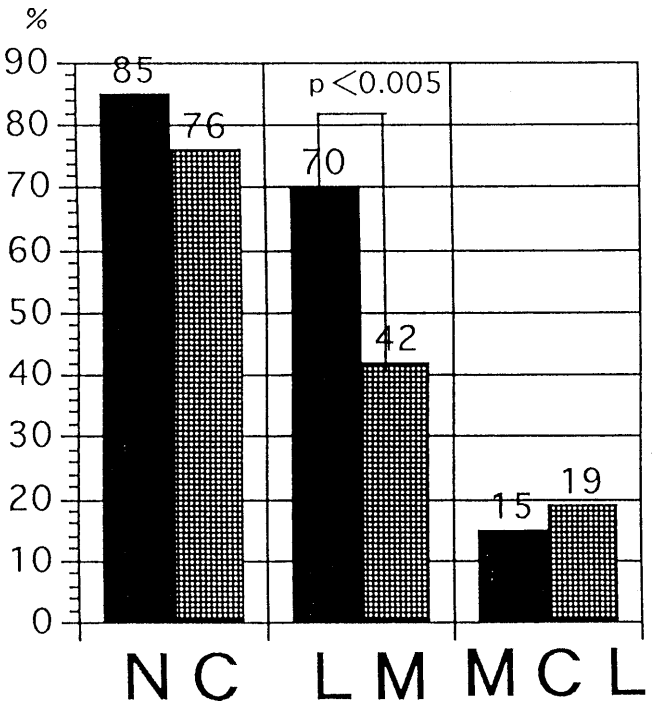

Fig. 4 Frequency of non-contact (*NC*) injury, lateral meniscal (*LM*) injury, and medical collateral ligament (*MCL*) injury in knees with (*black columns*) and without (*cross-hatched columns*) the abnormal notch

the presence or absence of preoperative "giving way," and the associated injuries were examined for all 216 knees.

The abnormal lateral notches were classified into three types. Type I was an abnormal notch located at the same site as the normal notch in the contralateral knee but that appeared to be deeper (Fig. 2a). Type II-A was an abnormal notch located at a site different from that of the normal notch in the contralateral knee (Fig. 2b). Type II-B was an abnormal notch flattened and widened towards the posterior in comparison with the normal contralateral notch (Fig. 2c).

The depth of the notch was defined as the distance from a tangential line to the lateral femoral condyle (Fig. 3). Statistical analysis was performed using the χ^2 test for independence.

Results

The abnormal lateral notch was found in 66 of 216 knees (30.6%), in 43 knees in males (35.2%) and in 23 knees in females (24.5%).

The type I notch was most frequent, and was found in 48 knees (73%), occurring at a depth of less than 1 mm in 16 knees (24%) and at a depth of 1 mm or more in 32 knees (49%). Type II-A and II-B notches were seen in 7 (11%) and 11 (17%) of knees, respectively.

Of the 66 knees with an abnormal notch, the ACL injury was caused by a non-contact mechanism in 56 (85%), and there was lateral meniscus injury in 46 (70%), medial collateral ligament injury (grade II or III) in 10 (15%), and a bone bruise on the lateral femoral condyle in 53 (80%). In the 150 knees without an abnormal notch, ACL injury caused by a non-contact mechanism was seen in 114 (76%), and there was lateral meniscus injury in 63 (42%), medial collateral ligament injury in 29 (19%), and bone bruise in 76 (51%) (Fig. 4).

The bone bruise was classified as being located in the region anterior to the abnormal notch the same region, or the region posterior to the abnormal notch. The bone bruise was located in the same region as the abnormal notch in 30 knees with a type I notch (62%); in knees with a type II-A notch, the bone bruise was in the same region as the abnormal notch in 2 knees (40%) and in the region posterior to the abnormal notch in 2 knees (40%). In knees with a type II-B notch, the bone bruise was in the region posterior to the abnormal notch in 6 knees (67%).

Of the 36 of the 216 patients, who remembered their knee position at the time of the injury, a type I notch was noted in 8 patients injured in the knee-extended position (89%), while in patients injured in the knee-flexed position, a type I notch was observed in 17 (63%), a type II-A notch was observed in 4 (15%), and a type II-B notch was observed in 6 (22%).

"Giving way" was experienced in 50% of the patients with the abnormal notch and in 45% of those without it.

Lateral meniscal injury was experienced in 109 of the 216 patients (46 with the abnormal notch; 63 without it).

The frequency of lateral meniscal injury was significantly higher in knees with the abnormal notch than in those without it ($P < 0.005$).

Discussion

The frequency of the abnormal notch was 30.6%, which was higher than previously reported, but may reflect our definition.

A number of authors have reported MRI findings in patients with ACL injury.[3,5,8,10,12,15–18] Graf et al.[5] observed bone bruises on the middle one-third of the lateral femoral condyle and on the posterior one-third of the lateral tibial condyle. Spindler et al.[17] noted bone bruises in 80% of knees with ACL injuries. They reported that 68% of the bone bruises were located in the lateral femoral condyle and the lateral tibial plateau. We have also frequently observed bone bruises in the lateral femoral and lateral tibial condyles in ACL injuries,[7] and bone bruises were evident in 81% of patients with an abnormal notch in the present study.

In this study, the rate at which patients experienced "giving way" did not differ significantly between those with or without an abnormal notch.

These findings indicate that the abnormal lateral notch occurred at the time of ACL injury. Judging from the location of the bone bruises on MRI and considering that the abnormal notch was significantly associated with a lateral meniscal injury, especially on the posterior segment,[4,9,13] we considered that the notch occurred at the site where the lateral femoral condyle impinged on the posterior edge of the lateral tibial condyle. However, some authors[8,19] have stated that the abnormal notch occurred when the lateral femoral condyle struck the anterior edge of the lateral tibial condyle during hyperextension of the knee.

In our study, bone bruises were highly prevalent in the same region as the abnormal notch in type I, and in the posterior region in type II. Also, the knee position at the time of injury was extension in 89% of patients with a type I notch. This indicates that knee extension injuries are highly prevalent in patients with type I notches, whereas knee flexion injuries are more prevalent in patients with type II notches.

Some osteoarthritic changes have been reported in ACL-injured knees,[2,6] and these changes may be correlated with cartilage damage at the abnormal notch. On the basis of arthroscopic findings, Noyes et al.[14] stated that a notch defect in the lateral femoral condyle appearred to cause gross chondral fibrillation or exposure of the bone. We have routinely examined the articular surface at the time of implant removal after ACL reconstruction, and have found that changes in the articular cartilage at the abnormal notch were further advanced than those seen at the time of reconstruction. Therefore, we will carefully observe such knees in the future.

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