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Spontaneous osteonecrosis of the lateral femoral condyle of the knee: a report of 11 cases

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Abstract
Background Spontaneous osteonecrosis (SON) of the lateral femoral condyle of the knee joint is very rare and there have been only a few articles about this condition.
Materials We reviewed data for 11 patients (7 men, 4 women) with unusual SON of the lateral femoral condyle of the knee. The average age of patients at onset was 61.9 years (range 47–76 years). No patient had underlying disease or had undergone steroid therapy, although one underwent lateral meniscectomy.
Results According to Aglietti's radiographic classification, three patients had stage 1 disease, two had stage 2 disease, three had stage 3 disease, one had stage 4 disease, and two had stage 5 at first examination. The average alignment of affected limbs on standing was 5.9° valgus (range 0°–11°). Although the osteonecrotic lesion was seen on the lateral side, the mechanical axis passed the medial compartment in three patients. Six patients were treated conservatively and the remaining five required surgery, which consisted of lateral unicompartmental knee arthroplasties.
Conclusion The pathology of the necrosis of the lateral femoral condyle was considered to be different from that of the medial femoral condyle regarding clinical features, limb alignment, and radiographic findings.

Keywords Spontaneous osteonecrosis · Lateral femoral condyle · Knee joint · Pathology · Treatment

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Introduction

Spontaneous osteonecrosis (SON) of the knee joint was first described by Ahlbäck et al. [1] and has been recognized as a distinct form of osteonecrosis. The lesion usually occurs in elderly women and is characterized by abrupt onset on the medial femoral condyle. This condition is also called primary osteonecrosis to distinguish it from secondary osteonecrosis, which is associated with systemic disorders or previous corticosteroid therapy. Secondary osteonecrosis is more frequently bilateral, usually involves multiple joints, and has different radiographic features.

Lotke and Ecker [10] divided the osteonecrosis-like syndromes that occur about the knee into four groups: (1) osteonecrosis of the medial femoral condyle, (2) osteonecrosis of the medial tibial plateau, (3) lateral syndromes (femur or tibia), and (4) lesions related to such conditions as bone necrosis in metabolic bone diseases, caisson disease, and steroid therapy. There have been many reports about the causes, pathology, treatment, and post-operative results of the most common SON on the medial femoral condyle. Although relatively rare, SON of the lateral femoral condyle, the patella, and the tibial plateau are also now recognized as pathologic entities. There have been several reports concerning the osteonecrosis-like syndrome of the medial tibial plateau [6, 9]. However, SON of the lateral femoral condyle occurs much less commonly and there have been only a few articles about the condition. In 1983 Aglietti et al. [3] reviewed 105 knees, including 104 of the medial femoral condyle and only one of the lateral. Marmor [11] reported on one case in which the lateral femoral condyle collapsed after medial unicompartmental knee arthroplasty (UKA) in 1984. Lotke and Ecker [10] reported that one of the 20 patients in their series had the lesion on the lateral side of the knee; they emphasized that the lateral

involvement was much less. However, the cause and pathology of lateral SON remains poorly understood. We report here on the pathology, clinical course, and treatment of this unusual SON.

Materials and methods

We treated 11 patients with SON of the lateral femoral between January 1999 and May 2007. Of the 11, 7 were men and 4 were women. The average age of patients at diagnosis was 61.9 years (range 47–76 years). The right knee was affected in eight patients and the left knee was in three. The average body mass index was 24.4 kg/m^2 (range 21.5–29.4 kg/m^2). None of the patients had a systemic causative factor causing the necrosis, such as alcoholism or corticosteroid therapy, but one patient had undergone previous lateral meniscectomy. The onset of pain was after activity, such as golfing or mountain climbing, in four patients. The remaining seven felt gradually increasing pain without heavy physical activity. However, no patients had severe pain, and all had less pain at night than during the day.

According to Aglietti's radiographic classification system [3], three patients had stage 1 (no radiographic findings) SON, two had stage 2 (a slight flattening of the condyle), three had stage 3 (a subchondral radiolucent lesion), one had stage 4 (a sclerotic halo and early collapse), and two had stage 5 (further collapse and secondary degenerative changes) at first visit to the hospital. The diagnosis of the patient with stage 1 was made on magnetic resonance imaging (MRI) or radionuclide bone scan. Two patients' SON deteriorated from stages 1 to 5, 15 and 26 months later. In two patients with stage 5, initial radiographs were not available. The characteristic findings of a calcified plate and sclerotic halo in the medial SON were not observed in patients with stage 4 disease. Instead, the subchondral bone of the lateral femoral condyle collapsed to the cystic form as the lesion proceeded to stage 4. The average alignment of the affected limb in supine was 4.7° valgus (range 0°–11°) and was 5.9° valgus on standing (range 0°–11°). The average percentage of passage of the mechanical axis on the articular surface [(length of passage from the tibial plateau medial edge/length of the entire tibial plateau) × 100] was 59.4% (range 31–83%) in one-legged stance. The mechanical axis passed the medial compartment in three patients (Table 1).

MRI showed that the involvement of the lateral femoral condyle was more extensive than could be appreciated on plain radiographs. On T_1-weighted images, the high-intensity image was replaced by a discrete subchondral area of low signal, sometimes surrounded by an area of intermediate signal intensity. On T^*_2-weighted images, an area of

Table 1 Patient demographics

	Case 1	Case 2	Case 3	Case 4	Case 5	Case 6	Case 7	Case 8	Case 9	Case 10	Case 11
Gender/age (years)	M/72	F/60	F/68	M/65	M/50	M/47	F/56	M/76	F/65	M/70	M/51
Body mass index (kg/m^2)	22.5	24.5	22.5	26.4	23.2	29.4	25.0	22.8	24.2	25.3	21.5
Event at onset of pain	Mountain climbing	No event, gradual onset	No event, gradual onset	Golfing	No event, sudden onset	No event, sudden onset	No event, gradual onset	Mountain climbing	No event, gradual onset	Golfing	No event, gradual onset
Radiologic stage	4	2	5	1	2	3	3	1	1	5	3
Limb alignment (degrees of valgus)	8°	6°	10°	11°	0°	0°	9°	10°	0°	5°	0°
%M	64.5	44.0	83.0	75.0	31.0	64.0	53.0	82.0	49.0	66.0	42.0
Treatment	UKA	Conservative	UKA	UKA	Conservative	Conservative	Conservative	UKA	Conservative	UKA	Conservative
Associated conditions	Previous lateral meniscectomy	–	–	Deterioration from stage 1 to stage 5	–	–	–	Deterioration from stage 1 to stage 5	–	–	–

%M = (length of passage from the tibial plateau medial edge/length of the entire tibial plateau) × 100

UKA unicompartmental knee arthroplasty

high-signal intensity of the necrotic lesion along with a linear subchondral focus of low-intensity signal was surrounded by a variable-size low signal thought to be edematous reaction to the lesion. In the early stages, the lateral meniscus was neither torn nor abnormally discoid, although it severely degenerated in patients with stage 4 or 5 disease on MRI. Scintigraphic studies using technetium 99 m were done in three patients and showed a well-localized increased focal uptake of isotope over the lateral femoral condyle.

One patient with stage 1, two patients with stage 2, and three patients with stage 3 diseases were conservatively treated by restriction of daily activities and sports. In five patients, symptoms resolved after several months of conservative care, but one patient with stage 3 had mild pain in the posterolateral area of the knee. However, the subchondral bone of the lateral femoral condyle did not collapse in patients treated conservatively. We performed lateral UKA in the remaining five patients. Of these, two patients' disease progressed from stages 1 to 5. At surgery, the segment of the lateral femoral condylar collapsed and the lateral tibial plateau degenerated. Histologic examination revealed a small area of necrotic bone and new bone formation in four of the five patients.

Case report

Case 4

A 65-year-old estate agent had right knee pain after playing golf in November 2001. His lateral SON was diagnosed on MRI examination and was treated conservatively. Although there was no abnormality on plain radiographs (Fig. 1a), MRI showed a small low-intensity subchondral area on the T_1-weighted image and a low-intensity subchondral area surrounded by high-intensity signal in the lateral femoral condyle on the T_2*-weighted image (Fig. 1b). The alignment of the limb on standing was 11° valgus. The patient presented with persistent, severe pain in the right knee in March 2002. On plain radiographs, it was apparent that the lateral femoral condyle had deteriorated from stages 1 to 4, but he refused surgical treatment. The patient continued to have severe pain and a necrotic bone collapsed, enlarged, and proceeded to stage 5 (Fig. 1c, d). In March 2003, a lateral UKA was performed using a M/G Uni-compartmental knee (Zimmer, Warsaw, IN) (Fig. 1e). A large osteonecrotic lesion with a flap of articular cartilage and subchondral bone anteriorly attached to the lateral femoral condyle was observed during surgery.

The diagnosis of SON was confirmed by pathologic evaluation of the specimen from the collapsed subchondral bone. The specimen revealed a small area of necrotic bone accompanied by new bone formation (Fig. 1f). It is possible that valgus alignment of the limb would aggravate the osteonecrotic lesion.

Case 5

A 50-year-old dentist visited our hospital in May 2003 for increasing right knee pain. He felt pain 2 months earlier when he awoke, and went to see another doctor. The pain did not respond to anti-inflammatory drugs and physiotherapy. On examination, he complained of dull pain from the lateral joint line to the posterolateral area. There were no joint effusion and instability; joint motion was normal. Plain radiographs showed a subtle radiolucency of the lateral femoral condyle, which was vivid on tomographs, located at the weight-bearing site. The radiographic lesion was graded as stage 2 (Fig. 2a, b). MRI revealed a low-intensity subchondral area on the T_1-weighted image and a high-intensity subchondral area surrounded by low-intensity signal on the T_2*-weighted image in the lateral femoral condyle (Fig. 2c, d). The limb alignment on standing was 0° valgus and the mechanical axis had passed the medial compartment of the knee. The patient was treated conservatively by restriction of sports activities.

Although there was abnormal signal in the lateral femoral condyle on MRI and he had slight pain 2 years after his first visit, the subchondral bone did not collapse. The necrotic bone was thought to still have stage 2 disease because of limb alignment.

Discussion

Since the first description of SON of the medial femoral condyle as a pathologic entity by Ahlbäck, various attempts have been made to identify the origin and complex natural history, pathology, and methods of treatment. They reported on 40 patients with an average of 70 years. The diagnosis was mainly based on increased focal uptake of isotope over the medial femoral condyle and on the exclusion of other known clinical entities, including osteochondritis dissecans, osteoarthritis, meniscal tear, and tumor. The diagnosis of osteonecrosis was supported by histopathologic findings for 7 of 40 patients who underwent needle biopsy.

The term "spontaneous" indicates that the precise etiology of this lesion is still unknown, although two theories of pathogenesis have been advanced. The vascular theory proposes that interference with microcirculation by unknown causes produces edema in the nonexpandable bone marrow compartment. The increased pressure further diminishes circulation, leading to osseous ischemia. This stage would correspond to low-intensity signal on T_1-weighted MRI

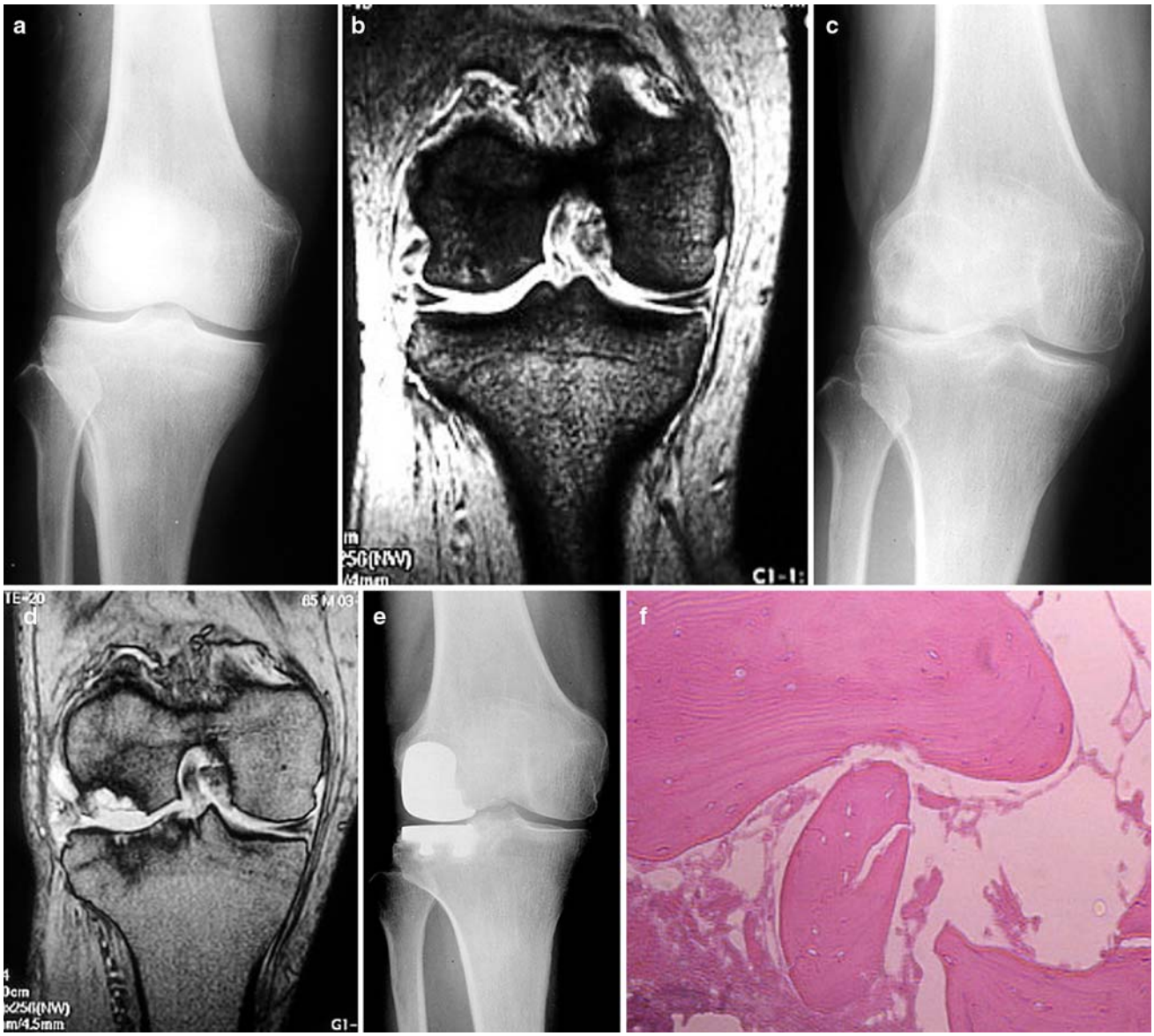

Fig. 1 Case 4: **a** plain radiograph of a lateral femoral condyle, no abnormality was apparent at the initial visit; **b** T_2*-weighted image; **c** the lateral femoral condyle deteriorated from stages 1 to 5 15 months later on plain radiograph; **d** T_2*-weighted image; **e** the lateral unicompartmental knee arthroplasty with an M/G Uni-compartmental knee; and **f** specimen showing a small area of necrotic bone accompanied by new bone formation

images. When the dead bone collapses, the typical radiographic lesions are visible. If revascularization occurs before collapse, the lesions may heal and the symptoms may resolve. Uchio et al. [18] reported that the intraosseous pressure of the medial femoral condyle was significantly higher than that in the lateral femoral condyle in patients with medial SON and than that of both femoral condyles in patients with osteoarthritis. They also found a marked disturbance of venous drainage in patients with medial SON on venogram. They hypothesized that venous stasis within the medullar canal in the condyle increased intraosseous pressure and decreased arteriovenous pressure, leading to osteonecrosis. However, they did not clarify the cause and process of venous stasis.

Trauma has been implicated as a cause of SON of the knee. In 1985, Lotke and Ecker [10] suggested microfractures within osteoporotic subchondral bone might be the underlying cause of SON. Most patients with SON are elderly, post-menopausal women who, therefore, may have osteoporosis; their limbs are mostly varus aligned. Microfractures may occur in the more susceptible subchondral bone. At this stage, bone scan findings would be positive, but MRI findings could still be normal. It has been reported that there may be a "window period" between the onsets of

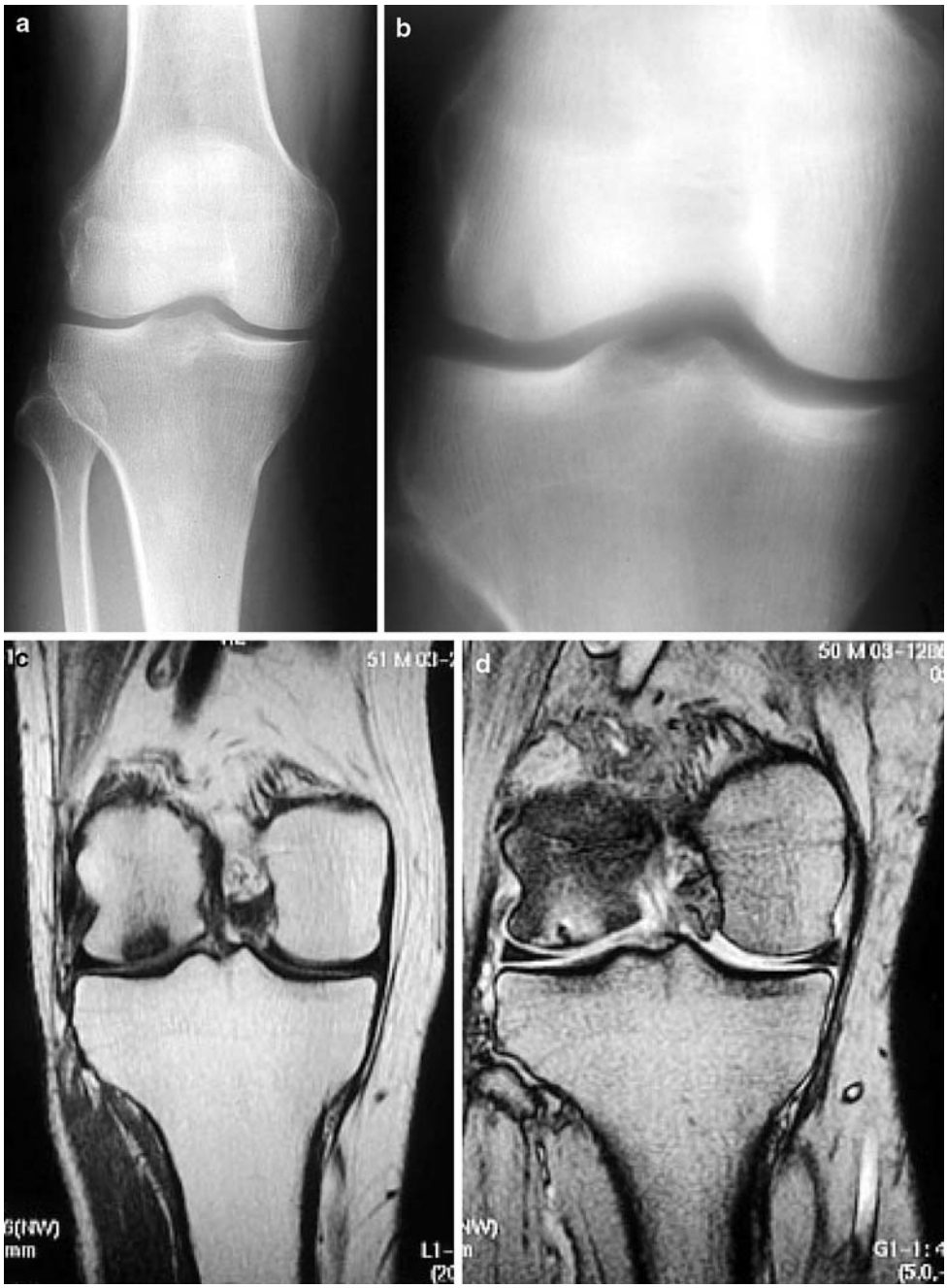

Fig. 2 Case 5: **a** plain radiograph, **b** subtle radiolucency of the lateral femoral condyle is vivid on tomograph, **c** T_1-weighted image, and **d** T_2*-weighted image

SON and its appearance on MRI scan [17]. Fractures weaken the subchondral plate and allow joint fluid to flow from the cracked articular cartilage into the subchondral bone. This would increase intraosseous pressure, create pain at rest or at night, and cause bone necrosis. The lesion would allow cysts to form and be an area for focal collapse of the bone, if large enough. The most convincing evidence is the pathologic evaluation of these lesions performed by Yamamoto and Bullough [19]. They reviewed the cases of 14 patients who had surgery for SON of the knee and evaluated the gross and histological morphology of the lesions. They concluded that the primary event leading to SON was subchondral insufficiency fracture and that the localized osteonecrosis observed in association with the lesions was the result of a fracture. Whereas SON occurs mostly in the medial femoral condyle of the knee, lateral SON is rare. As a result, there are few reports on its cause, pathology, natural course, and treatment. Al-Rowaih et al. [2] reported that of 40 patients with SON of the knee, the medial femoral condyle was affected in 37 and the lateral femoral condyle in 3. Motohashi et al. [13] observed that in two patients without severe valgus deformity (4° valgus angulation and 0.5° varus), SON did not progress regardless of the size of necrotic area. Forst et al. [7] treated 16 patients with early

stage of SON (11 with medial involvement and 5 with lateral) surgically by extra-articular drilling into the affected femoral condyle to achieve core decompression. However, there were no description about pathology, clinical features, and radiographic findings in detail.

In addition to lateral SON, other conditions produce similar radiographic or MRI findings. Findings on MRI indicative of SON include a linear low-signal margin and reactive bone marrow edema on T_2*-weighted images that can resemble an insufficiency fracture [8, 17]. This MRI appearance differs from that of a typical avascular osteonecrosis seen in the femoral head because it lacks the cardinal feature of epiphyseal osteonecrosis, i.e., the demarcation rim or reactive interface that separates necrotic bone marrow from adjacent viable tissue. Diffuse bone marrow edema is characterized by ill-defined area of diminished signal intensity on T_1-weighted MRI and of intermediate to high-signal intensity on T_2*-weighted images. This pattern itself is a non-specific findings encountered with several entities including transient osteoporosis, SON, bone contusion, stress fracture, and osteoarthritic reactive changes. However, patients with stage 1 were diagnosed as lateral SON by a linear low-signal margin in the subchondral bone on T_2*-weighted MRI.

In the present study, lateral SON was shown to have several clinical and radiographic features different from medial SON, although the number of patients studied was limited. Clinically, lateral SON does not occur more frequently in women than in men and sometimes it occurs in middle-aged patients without porotic bones. The pain is not usually abrupt, severe, or worse at night, and the lower extremity is not always valgus-aligned. Thus, it is difficult to explain the traumatic theory of microfractures within osteoporotic bone as the etiology of lateral SON. Radiographically, the characteristic appearance of stage 4 medial SON, such as the presence of a sclerotic halo with a calcified plate, is not observed. The lesion may collapse to the cystic form and may occur somewhere other than the weight-bearing site of the lateral femoral condyle. Furthermore, the patients in the current study with valgus-aligned limbs showed rapid progression of SON, leading to bone collapse and degenerative changes within a short period. In two patients with 10° and 11° of valgus alignment, SON deteriorated to stage 5 within 6 and 15 months, respectively, of onset (cases 3 and 4).

Treatment of lateral SON depends on the stage and size of the radiographic lesion. In general, stages 1, 2, and 3, the early stages, are potentially reversible or show no progression, whereas stages 4 and 5 are end stages in the course of disease and are associated with irreversible destruction of the subchondral bone and articular cartilage. Patients with early stages may be treated conservatively, which includes protected weight-bearing while their symptoms are acute, restriction of sports activities, and the use of anti-inflammatory drugs. Patients without a severely valgus-aligned limb can be successfully treated with conservative care alone. Gradually, the symptoms subside, and usually any surgery can be avoided. For faster healing, arthroscopic surgery may be suitable for early stage pathology because it is less invasive. Forst et al. treated five patients with early stage lateral SON and recommended core decompression by extra-articular drilling into the femoral condyle as an effective treatment [7]. Perez Carro et al. [16] successfully treated a 49-year-old man with radiographic stage 2 SON by arthroscopically intra-articular core decompression and bone grafting.

For patients with stage 4 or 5 disease, surgery is usually indicated. When the patient is younger than 60 years and has high physical demands, osteotomy is recommended rather than arthroplasty. When the osteotomy is performed on the tibial side in lateral SON, unacceptable joint obliquity may occur after surgery and have unsatisfactory and unpredictable results because the lesion in lateral SON occurs on the femoral side. To prevent the post-operative obliquity of the joint, femoral supracondylar osteotomy is preferable [14]. However, some surgeons have reported that the surgical technique and post-operative rehabilitation are difficult. Complications including delayed union or nonunion of the osteotomy and joint stiffness requiring manipulation after femoral osteotomy have been reported [5].

If the medial compartment is well preserved and the patient is older than 60 years, UKA is recommended. The long-term results of lateral UKA are favorable, and loosening of the implant has not been observed as commonly as in medial UKA [4, 12, 15]. The ideal alignment in lateral UKA is slight valgus. Even so, deterioration of the medial compartment may occur after lateral UKA. Surgeons may choose total knee arthroplasty (TKA) instead of UKA because the medial and patellofemoral compartments gradually deteriorate. The choice between TKA and UKA is a subject of major debate. However, there are several potential advantages to UKA compared with TKA, including more normal gait patterns, better range of motion, less soft-tissue dissection, less blood loss associated with lower complication rates, and preservation of bone stock and the cruciate ligament. If the medial compartment becomes involved and the valgus deformity is not correctable before surgery, TKA is the treatment of choice.

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