Chapter 15
Tibiofemoral Cartilage Defect with Malalignment

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Chief Complaint

Medial knee pain

History of Present Illness

The patient is a 34-year-old otherwise healthy and athletic, non-smoking female who is a passionate water skier and teacher presents with 2 years of atraumatic pain in the medial side of the knee. She reports temporary swelling of the joint and pain after activity and sometimes during weight-bearing along the medial aspect. She denies any feeling of instability. She has occasional swelling and stiffness that resolve overnight. She reports having a partial medial meniscectomy 10 years ago. Nonoperative treatment with ice, elevation, and anti-inflammatory medications did not provide lasting relief.

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Pearls

- History of partial meniscectomy: Partial meniscectomy is a risk factor for chondral degeneration. Particularly pain after activity is an indicator of possible degenerative changes rather than an acute injury.

Physical Examination

The patient has a normal BMI of 23.5. She walks with a normal gait and gross macroscopic alignment of the lower extremity shows varus deformity. The right knee has no effusion, soft tissue swelling, erythema, or warmth. The range of motion is from 0° to 135°. There is tenderness to palpation over the medial compartment diffusely more along the proximal tibia than the joint line. Meniscal tests (flexion, compression, rotation) are negative. There is good patellofemoral tracking without crepitus. The ligamentous examination shows no abnormalities. The neurovascular examination is within normal limits.

Pearls

- Medial-sided symptoms: Medial-sided symptoms may have their origin in the joint but can also come from other medial structures such as pes anserine bursitis, a meniscal cyst, or medial collateral ligament injury. A comprehensive exam is important to delineate if this is specific to the joint line or proximal or distal to the joint. Questions related to the pain before, during, and after activity are an important discriminator regarding acute and chronic as well as stable and unstable meniscal injuries. Finally, medial overload can also cause generalized medial-sided pain. Inspection of the gait and alignment should be done in all cases.

- Effusion: Any effusion is suspicious for chondral damage. Effusions that are not self-limited may be more synovial irritation and can happen with OA, RA, or severe overloading. Effusions that resolve overnight and reoccur with specific events may be structurally related to a chondral or meniscus injury.

Imaging

Imaging with standard x-rays of the knee (AP and lateral) is obtained to evaluate for avascular necrosis, osseous lesions, or joint space narrowing. In this case, the plain radiographs show low-grade medial joint space narrowing (2 mm). The long-leg alignment (MTP-2) view shows varus malalignment of 6°. Due to the normal joint space on radiographs, an MRI was ordered to assess the articular cartilage and meniscus status and showed a 2 cm^2 chondral defect in the medial femoral condyle with an intact subchondral bone plate. There were also findings consistent with a prior partial medial meniscectomy. There is no evidence of damage to the lateral meniscus or the ligaments.

Pearls

- Varus malalignment: Alignment plays an important role in decision-making, as malalignment can predispose to overloading on either side of the joint. A clinical diagnosis of axial deformity should be verified with a single leg weight-bearing (MTP-2) long-leg alignment x-ray.

Approach to Treatment

The following aspects should be considered in this young active patient with persistent symptoms related to a symptomatic cartilage lesion of the medial femoral condyle with varus malalignment and prior meniscal deficiency:

1. Evaluating alignment is crucial for the treatment planning. This patient has a varus deformity with a concomitant chondral lesion on the medial side. The choice to include osteotomy typically requires the weight-bearing line to be in the affected joint compartment.
2. The patient is status post partial medial meniscectomy, which puts her at increased risk of early medial osteoarthritis. If the diagnostic arthroscopy shows a re-rupture of the medial meniscus, this should be debrided judiciously. If a subtotal or total meniscectomy is needed, meniscus transplantation should be considered due to the young age of this patient. The patient should be counseled regarding having a higher risk of advanced medial osteoarthritis in the future with a need of joint replacement surgery. It should be clearly conveyed that this procedure is performed to alleviate her symptoms and prevent an early replacement surgery.
3. Though the evidence can be inconsistent, treating the cartilage lesion in conjunction with the malalignment is typically recommended. The type of cartilage modality that is chosen is likely secondary to the fact that it should be addressed in some way.
4. Patient's ability and willingness for compliance should not be noted. Especially, the limited weight-bearing following the osteotomy should be discussed carefully.

In case of a combination of malalignment with cartilage abnormalities, the primary objective should be the correction of the alignment. A thorough analysis of the long-leg standing radiographs must be done to determine how to correct the deformity. The genu varum arises typically from the tibia; however the distal femoral angle should be measured as well.

If the origin is from the proximal tibia, either a medial open-wedge or lateral closing-wedge high tibial osteotomy (HTO) can be performed. The movement of the tibia into valgus reduces the forces acting onto the medial compartment, at the expense of increased lateral cartilage stress. Therefore it should be kept in mind that overcorrection can lead to rapid degeneration in the lateral compartment [1]. A recent study by Tsukada et al. showed no significant differences in terms of the ratio of cartilage repair tissue in the medial compartment between 17 overcorrected knees with mean deformity of 15° ± 1° and 54 moderately corrected knees with mean deformity of 10° ± 2° after open-wedge HTO [2].

With appropriate patient selection, accurate preoperative planning, modern surgical fixation techniques, and rapid rehabilitation, it is an effective biological treatment for degenerative disease, deformity, and knee instability and also as an adjunct to other complex joint surfaces and meniscal cartilage surgeries [3]. Bonasia et al. analyzed prognostic factors and showed that advanced age, possibly obesity and failure to regain adequate postoperative motion, may predispose to early failure. On the other hand, younger patients with good knee function and only mild degenerative joint disease appear to be ideal candidates for this procedure [4]. In critical or borderline indications, the temporary use of an unloading valgus producing knee brace may well predict future outcome of HTO surgery in terms of expectable postoperative pain relief [5]. A lateral closing-wedge HTO is usually performed for osteoarthritis patients with no morphotype alterations and with light or moderate deformity. However, it is more difficult to change the tibial slope. Additional factors that influence the choice of osteotomy include age, bone quality, patellar height, and functional demand. Patients at risk for nonunion, such as patients with a high BMI or smokers, should be strongly considered for closing-wedge osteotomy, if as surgical candidates at all [6]. Relative and absolute contraindications for osteotomy include significant osteoarthritis and cartilage/meniscus lesion in the contralateral compartment, bone loss of more than 3 mm in the affected compartment with high risk of subsequent joint instability, reduced range of motion with more than 10° extension loss, less than 90° of knee flexion, more than 20° of need for correction, advanced knee instability, morbid obesity, smoking and rheumatoid arthritis, or other systemic joint disease [7]. The relationship of smoking and outcomes from articular cartilage surgery in the knee suggests an overall negative influence [8]. Regarding cartilage regeneration, a recent study demonstrated cartilage regeneration after opening-wedge valgus HTO, which was affected by BMI, preoperative cartilage degeneration grade, and postoperative limb alignment. The authors underlined that patient selection based on BMI rather than age should be considered [9].

The preservation of the tibiofibular joint and the posterolateral structures along with easier adjustment of the tibial slope are the main advantages of the medial open-wedge HTO. The disadvantages lie in the risk of correction loss and nonunion together with longer rehabilitation due to limited weight-bearing. On the other hand, lateral closing-wedge HTO allows earlier weight-bearing and has less risk of nonunion and loss of correction. However, closing-wedge osteotomy alters the tibial shape, which can complicate subsequent arthroplasty [6]. Complications include neurovascular injuries (peroneal nerve), as the most serious ones, along with non-/malunion, infection, deep vein thrombosis, and intraoperative fracture of the tibial plateau [10].

Retrospective analysis of 533 patients revealed favorable midterm results after valgus HTO in varus osteoarthritis even in older patients with a high degree of cartilage damage [11]. Jung et al. demonstrated that the degenerated cartilage of the medial femoral condyle and medial tibial plateau could be partially or entirely covered by newly regenerated cartilage at 2 years after adequate correction of varus deformity by medial opening-wedge HTO without cartilage regeneration strategies [12]. However, these results should be interpreted with caution due to short-term follow-up and sole macroscopic evaluation without histology. Other studies with short-term follow-up reported promising results [13, 14]. Bode et al.

analyzed the outcome in 51 patients and reported a survival rate of over 96% at 5 years, concluding HTO as a reliable treatment option with satisfying and stable clinical outcome following 60 months [15]. Hantes et al. demonstrated that medial open-wedge HTO with a locking plate is an effective joint preservation method to treat medial compartment osteoarthritis in active patients younger than 45 years with satisfactory clinical and radiological results along with a 95% survival rate 12 years postoperatively [16]. A study on sporting activity following HTO for the treatment of medial compartment knee osteoarthritis in the active patient demonstrated favorable clinical results and allowed patients to return to sports and recreational activities similar to the preoperative level [17].

Despite the abundance of literature favoring the utilization of open-wedge HTO for varus knee deformity, Kanamaya et al. showed improved JOA scores after short-term follow-up following closing-wedge osteotomy [18]. Furthermore, a recent study comparing both techniques demonstrated favorable clinical outcomes for patients who underwent a closed-wedge osteotomy after a mean follow-up of 7.9 years [19].

The chondral damage of the medial compartment in patients with repairable chondral defects and no established OA should be addressed at the time of osteotomy [20]. In the United States, HTO was performed at a significantly higher rate in conjunction with autologous chondrocyte implantation and open osteochondral allograft [21]. However, in this chapter, we will focus on marrow stimulating therapy. Parker et al. showed in an MRI follow-up study on patients following medial opening-wedge HTO that after a non-weight-bearing period, the rate of change in the medial compartment changed from negative to positive, indicating the potential for articular cartilage recovery secondary to an improved mechanical environment [22]. Early results following HTO with an external fixator and microfracture for the varus knee with medial chondral wear in 33 patients led to significant improvements in WOMAC and Lysholm scores [23]. The combination of HTO and chondral resurfacing on 91 knees with a minimum follow-up of 5 years was deemed effective in the treatment of severe medial osteoarthritis and varus malalignment as a high survival rate of 95.2% was found indicating that arthroplasty can be initially postponed in most of these patients [24]. On the contrary, another study showed that subchondral drilling had no effect on the outcome at 2 years after medial open-wedge HTO [25]. Akizuki et al. showed that 64% of the regenerated tissue following abrasion arthroplasty for medial compartment osteoarthritis with eburnation in patients undergoing HTO consisted of fibrocartilage at around 12 months after surgery. However, there was no difference in the clinical outcome at 2–9 years postoperatively between the patients with and without concomitant cartilage therapy [26].

A survivorship analysis showed 91% survivorship at 7 years with patients who proceeded to knee arthroplasty after combined HTO/microfracture had a mean delay of 81.3 months. The authors noted that patients with medial meniscus injury at surgery were 9.2 times more likely to undergo arthroplasty than patients without [27]. This underlines the importance of providing the patient in our case scenario with sufficient information as her history of partial meniscectomy puts her at increased risk for failure. Harris et al. could show in 18 patients undergoing varus or valgus osteotomy combined with meniscal transplantation and articular cartilage surgery a statistically significant and clinically meaningful improvement in clinical outcome scores at long-term follow-up. Although there was a low rate of cartilage or meniscal revision (or both) and total knee arthroplasty, there was a high rate of reoperation [28]. This underlines the importance of meniscal preservation in this patient population.

Kim et al. showed microfracture with collagen augmentation was superior to that after microfracture in terms of the cartilage repair quality in patients undergoing HTO despite the clinical results not reflecting this difference in tissue repair after 1 year [29]. The histological evaluation of the articular cartilage from the medial compartment after arthroscopic subchondral drilling followed by postoperative intra-articular injections of autologous peripheral blood stem cells and hyaluronic acid with concomitant medial open-wedge HTO in patients with varus deformity of the knee joint demonstrated regenerate that closely resembled the native articular cartilage [30]. Another study showed that intra-articular injection of cultured mesenchymal stem cells is effective in improving both short-term clinical and MOCART outcomes in patients undergoing HTO and microfracture for varus knees with cartilage defects [31]. However, studies with longer follow-up are needed to add more substantial evidence to these newer treatment methods.

The advantages and disadvantages of the techniques can be depicted in Table 15.1.

Table 15.1 Different therapeutic approaches

Technique	Advantages	Disadvantages
Marrow stimulation procedure without osteotomy	Easy to perform Uncomplicated postoperative rehabilitation	Short-term benefit Only temporary relief
Cartilage procedure with osteotomy	Long-lasting functional outcome Treatment of the underlying cause Possible conversion to other treatment options later on, if needed	Strict postoperative rehabilitation with limited weight-bearing Enhanced risk of complications including nonunion
Unicondylar knee replacement	Early symptom relief	Burns the bridges for any reconstruction in the future High likelihood that the patient will need a revision replacement surgery at some point in the future

Technique Description

Due to the abovementioned arguments, the preferred treatment for this patient is an arthroscopy followed by a high tibial valgus osteotomy. The patient is positioned supine on the operating table. During diagnostic arthroscopy, a full-thickness 10 mm by 20 mm chondral lesion of the medial femoral condyle within the weight-bearing zone in extension is identified (Fig. 15.1). After confirming the absence of any ligamentous lesion, a microfracture procedure is performed (Fig. 15.2). The stability testing of the medial meniscus with the probe does not show any re-rupture, which would require further treatment (Fig. 15.3).

Following the arthroscopy, a 7–8 cm incision is made between the tibial tuberosity and the posteromedial border of the tibial joint line (Fig. 15.4). The sartorius fascia is incised longitudinally above the semitendinosus attachment in the pes anserinus. After releasing the hamstrings from the tibia and partially detaching the superficial medial collateral ligament, a Hohmann retractor is inserted along the posterior tibia. Agneskirchner et al. could show in a biomechanical study that a complete release of the distal fibers of the MCL is necessary after valgus opening-wedge HTO for effective decompression of the medial joint space [32]. The utilization of the Hohmann retractor serves for the protection of the neurovascular structures in the posterior compartment. Under fluoroscopic control, a 2 mm Kirschner wire is introduced at the metaphyseal-diaphyseal transition zone of the medial tibia toward the tip of the fibular head (Fig. 15.5). It is important to stop drilling as soon as the lateral cortex is reached in order not to injure the peroneal nerve. Another Kirschner wire is placed parallel to the first one along the planned osteotomy level. Next, a calibrated saw is used for the horizontal cut with an end approximately 1 cm medial to the lateral cortex. It is important to complete the osteotomy of the posterior cortex. Then, an anterior ascending cut is made posterior to the tibial tuberosity (TT). Care must be taken not to injure the patellar tendon or induce a detachment of the TT. The TT fragment should have

Figure 15.1 Long-leg alignment film indicating varus malformation of the left knee

a minimum thickness of about 10 mm to minimize the risk of fracture (Fig. 15.6). Despite the usefulness of the calibrated saw, an image intensifier should be utilized as needed to make the correct cuts. With growing experience, the surgeon will be able to limit the dose of radiation to the patient. After the completion of the osteotomy, an osteotomy chisel is inserted into the transverse osteotomy above the Kirschner wires up to

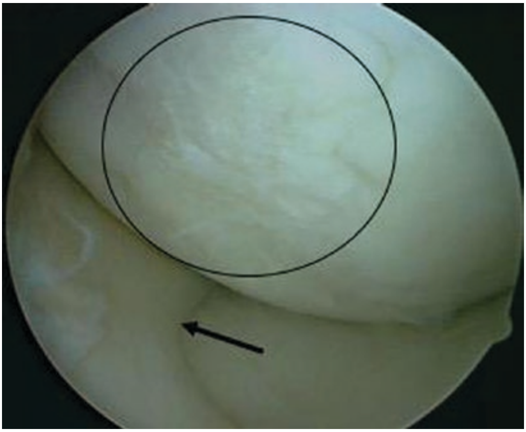

Figure 15.2 Grade 3a chondral lesion on medial femoral condyle of the left knee (circle indicating 2 × 2 cm area). Arrow indicating normal anterior and middle contour of the medial meniscus

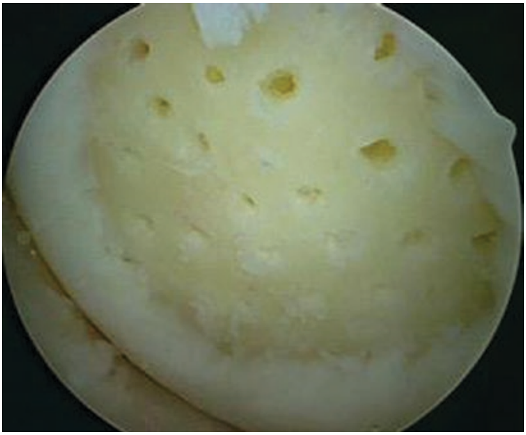

Figure 15.3 Microfracture treatment of the chondral defect after debridement of the defect to the subchondral bone and stabilization of the edges

FIGURE 15.4 Medial-sided incision approximately from the joint line to about 2–3 cm distal of the tibial tubercle

the lateral bony hinge with careful hammering. Then a second osteotomy chisel is inserted between the first chisel and the guidewires. Additional chisels are inserted between the first two for gradual spreading of the osteotomy. The desired correction is achieved using a spreader introduced into the most posterior part of the osteotomy site. This enables the creation of a trapezoidal gap to minimize the risk of tibial slope increment. As shown in a 3D finite element model, joint line obliquity of more than 5° induces excessive shear stress in the tibial articular cartilage. Thus, attention should be paid to joint line congruity [33]. After adequate correction, the chisels are removed, and the alignment can be checked with the help of a rod connecting the center of the femoral head with the ankle joint center under image intensifier. Next, a 4.5 mm locking plate is inserted subcutaneously on the medial proximal tibia.

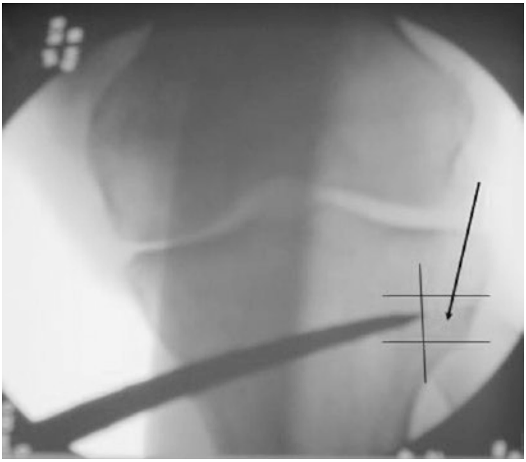

FIGURE 15.5 Under fluoroscopy the guidewire is inserted to be positioned in the lateral target zone. It should be located within 1 cm of the lateral cortex between the tip of the fibula and the base of the fibula. This will protect against lateral breakout. The osteotome (visible here) will follow the guidewire

The shaft portion must be in line with the tibial diaphysis to avoid overhang in the anteroposterior direction. The plate must bridge the osteotomy, and the proximal part must be positioned parallel to the slope approximately 1 cm subchondral to the joint line. After the correct positioning, the plate is secured by insertion of a Kirschner wire into the central drill sleeve in the proximal portion. After fixation of the proximal part of the plate with locking screws, the distal part is fixed with the knee in full extension (Fig. 15.7). If needed, the lateral hinge can be compressed with the help of a cortical screw before the fixation of the distal part. Once the fixation was finished, the spreader is removed. The osteotomy gap can be filled with allograft bone or autograft. A systematic review of opening-wedge osteotomies showed good short-term to mid-term outcomes with acceptable complication rates. The lowest rates of delayed union/nonunion were in autograft bone-filled

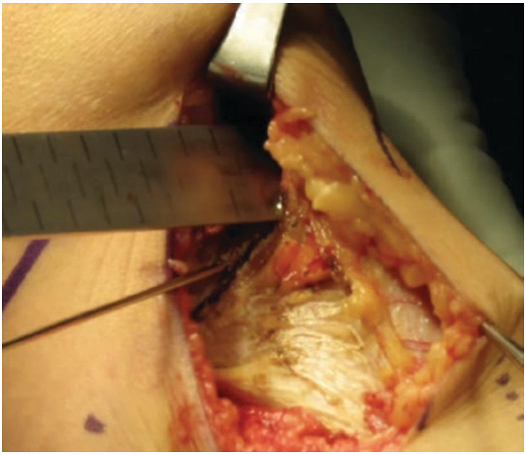

Figure 15.6 With the guidewire positioned, the biplanar osteotomy is begun using an Army-Navy retractor to elevate the patellar tendon and carefully scoring the tubercle toward the osteotomy plane in a slightly a-/p-angled position. The osteotomy should be positioned such that the tubercle is not thinner than 1 cm to prevent fracture of the tubercle

osteotomies [34]. After the procedure, the medial collateral ligament and the hamstring tendons will be covered by the plate.

Postoperative Rehabilitation Protocol

Following surgery, the patient is mobilized with partial weight-bearing (10–15% of current weight) on crutches for 6 weeks followed by gradual increase of weight-bearing in the following weeks. Quadriceps strengthening exercises are started immediately. She is placed on continuous passive motion without limitation for 6 weeks at 4 hours per day. Concomitant physiotherapy is initiated with focus on reducing the inflammation.

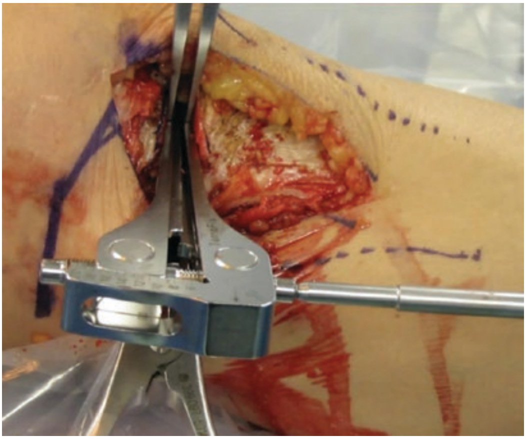

FIGURE 15.7 The osteotomy plane is carefully cut up to within 1 cm of the lateral cortex and a wedge (in this case a variable pitch wedge) is inserted to open up the osteotomy to the predetermined angle or mm distance. Then the fixation of choice can be utilized to secure the osteotomy in place. It is important that the osteotomy cleft is equal all along or wider posteriorly than an anteriorly in order not to decrease the posterior tibial slope

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