Patellofemoral Disorders

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Introduction

Pathology involving the patellofemoral joint is a common complaint among patients seeking orthopedic evaluation, and due to the wide spectrum of potential causes, its management can be challenging for both patients and providers [1, 2]. Identifying specific causes of and potential interventions for patellofemoral disorders requires a solid understanding of the anatomic components which comprise this area of the knee. The osseous elements of the patellofemoral joint consist of the femoral trochlea and the patella. The relative position of the tibial tubercle and the rotatory orientation of the tibia and femur are also important, however, and can significantly affect overall patellofemoral function [3]. The primary soft tissue structures involved in patellofemoral disorders include the medial patellofemoral ligament (MPFL), the lateral patellar retinaculum, and the quadriceps muscle, specifically the vastus medialis oblique (VMO).

The first step in the diagnosis and treatment of patellofemoral disorders is a thorough history and clinical examination. Some patients report insidious onset of pain in the patellofemoral region without a discrete history of knee injury, while others report a history of one or more patellar dislocation events which may or may not require formal reduction. It is important to differentiate between complaints of pain alone versus those including instability and to define the differences between subjective and objective instability [4]. Pain symptoms are commonly exacerbated when the knee is in positions of deep flexion, such as going up- or downstairs, or when standing up from a seated position. Instability symptoms may be elicited by a variety of activities, including both sports and activities of daily living.

Physical examination of the knee begins with an assessment of the overall limb alignment, to look for evidence of varus or valgus knee orientation, rotational abnormalities of the femur or tibia, and the relative height of the patella in relation to the knee joint. Any evidence of muscular atrophy or asymmetry, specifically of the VMO, should be noted, along with the presence of any joint effusion. Next, a dynamic observation of the patellofemoral joint should be completed, documenting the tracking of the patella as the knee is actively brought through a flexion–extension arc. This may identify a pathologic “J” sign, reflecting lateral displacement of the patella at the extended knee position. The Q angle, measured as the angle of pull between the quadriceps mechanism and patellar tendon, should also be assessed. Provocative examination tests for the patellofemoral joint include evaluation of patellar tilt, which can identify problems with excessive tightness or laxity of the lateral retinaculum, and patellar apprehension, in which the examiner attempts to displace the patella laterally and looks for a reflexive tightening of the quadriceps muscle in the attempt to pull the patella back in the medial direction. Similarly, assessment of patellar glide can provide information about the overall laxity of the patellar restraints. Finally, the patellar grind test, in which the examiner depresses the patella against the trochlea while moving the knee through a flexion–extension arc, may provide evidence of chondromalacia within the patellofemoral joint.

The initial imaging of patellofemoral disorders consists of standard PA, lateral, and merchant views of the knee. If indicated, mechanical alignment films may also be obtained to assess for excess varus or valgus [3]. In the clinical setting of acute patellar dislocation, it is important to rule out the possibility of a displaced osteochondral fragment, which may occur either during dislocation or relocation of the patella. Lateral radiographs are essential in the assessment of trochlear morphology, and as described by Dejour, the crossing sign, supratrochlear spur, and double contour may

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indicate trochlear dysplasia [5]. Dejour's classification of trochlear dysplasia describes four types of morphology [5]. The lateral radiograph can also be assessed for evidence of patella alta or baja, using the Caton–Deschamps ratio or Insall–Salvati ratio [6]. Merchant views allow assessment of the patellar tilt and patellar subluxation, which may be abnormal in the setting of an excessively tight retinaculum [7].

Cross-sectional imaging is also an important tool in the radiographic assessment of patellofemoral disorders. The tibial tubercle–trochlear groove (TT-TG) distance measures the lateral offset of the tibial tubercle relative to the deepest portion of the trochlea, and a TT-TG greater than 20 mm is associated with patellar instability [4]. Magnetic resonance imaging (MRI) is useful in the evaluation of both chondral lesions and medial patellofemoral restraints. MRI has been found to be 85 % sensitive and 70 % specific for evaluation of MPFL ligament disruption and 83 % sensitive and 84 % specific for detecting grade II, III, or IV chondromalacia of the patella [8, 9].

For many patients with patellofemoral disorders, an initial nonoperative trial with rest, nonsteroidal anti-inflammatories, and physical therapy may be effective in relieving symptoms [10–12]. However, in patients with chronic instability or multiple dislocation events, and in those patients with significant chondral lesions, surgery may be indicated [13–19]. This chapter will utilize a case-based format to highlight the most common operative strategies used in the treatment of patellofemoral disorders, with correlations drawn between clinical, radiographic, and MRI findings and observations made at the time of surgery. Three cases will be presented, including:

1. Patellar maltracking requiring tibial tubercle osteotomy and MPFL reconstruction
2. Chronic patellar instability requiring trochleaplasty (bilateral)
3. Chronic patellar and trochlear cartilage defects requiring allograft cartilage transplantation with the particulated juvenile chondrocyte implantation technique

Case 1

History/Exam

A 40-year-old female presented to clinic for evaluation of long-standing left knee patella instability and pain, with 1 month of locking and catching when arising from a chair. The patient reported a history of a probable patellar dislocation which occurred in high school during an ice skating twisting injury. Her initial treatment at that time was with bracing for 1 month. Since then, the patient reported multiple subluxation episodes without a frank dislocation. Treatments consisting of rest, activity modification, NSAIDs, bracing, and therapy had not provided adequate relief, forcing her to give up certain activities such as jogging. On examination, there was a significant patellar grind, a crepitus, and a Q angle of 20. There was no significant joint effusion. On testing of the MPFL, there was a soft endpoint with lateral patellar translation and apprehension.

Imaging

Based on the patients' physical examination and history, plain radiographs and MRI were obtained for confirmation of the diagnosis and possible surgical planning. Initial imaging of the knee confirmed excessive lateral patellar tilt and subluxation, with moderate degenerative changes of the lateral patellar facet (Fig. 9.1a–c). A complete sequence of MRI imaging without contrast was obtained. Axial T2 magnetic

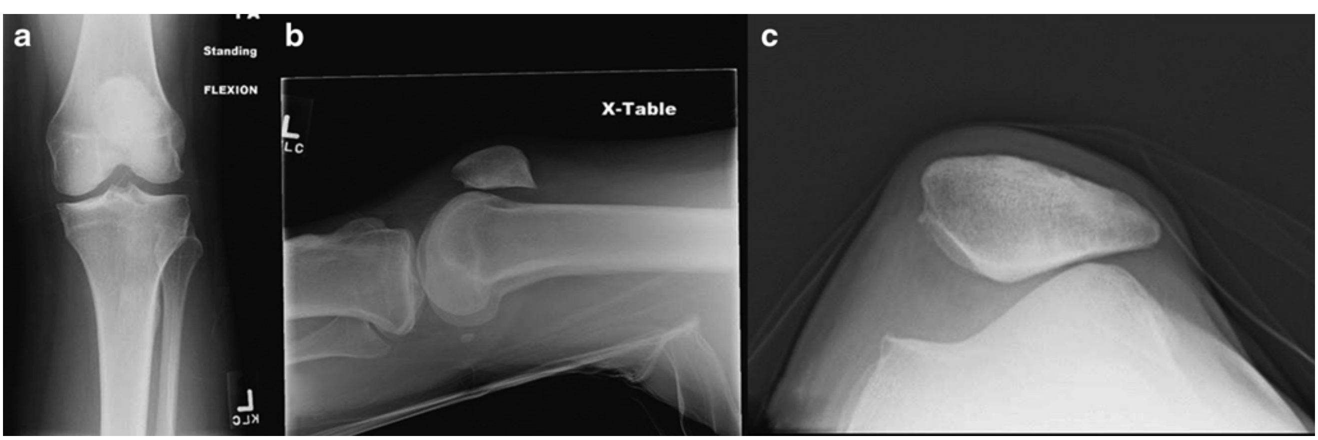

Fig. 9.1 (**a**–**c**) PA, lateral, and merchant views of the left knee, demonstrating excessive patellar tilt and subluxation, with moderate degenerative changes of the lateral patellar facet

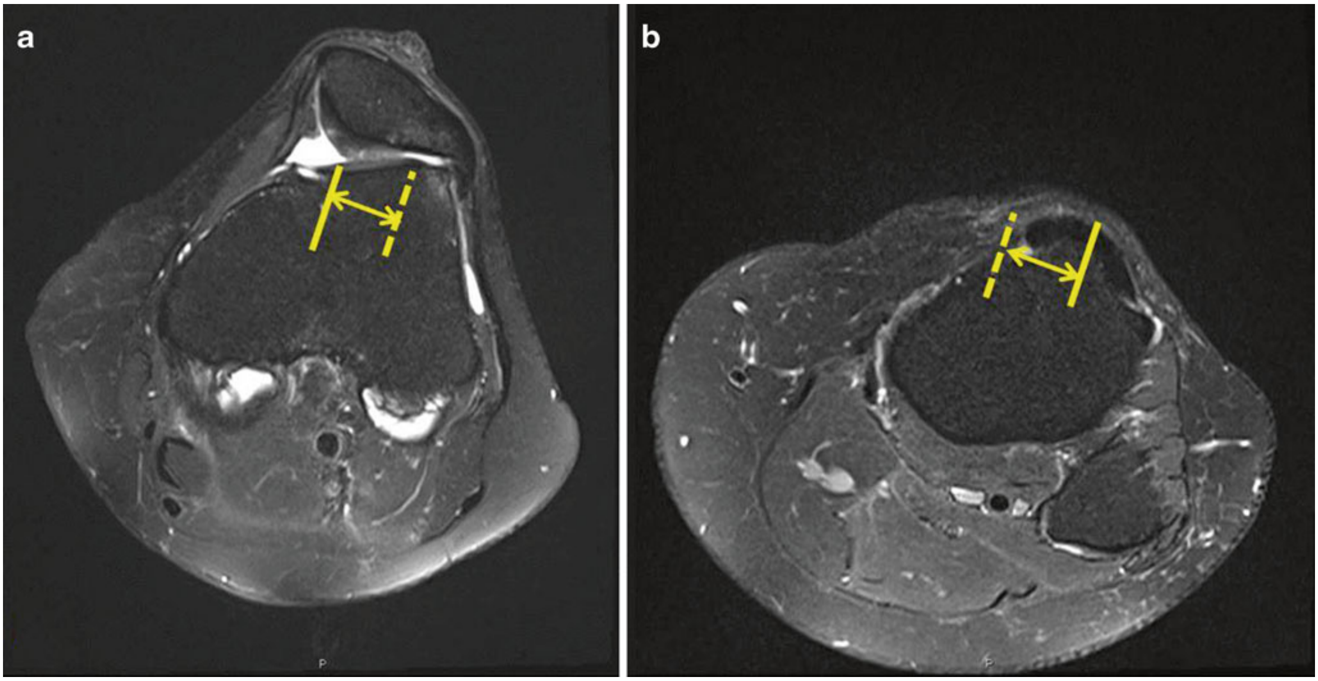

Fig. 9.2 (**a**, **b**) MRI demonstrating increased TT-TG distance and patellar malalignment. *Solid line* demonstrates trochlear groove in **a** and tibial tubercle in **b**. *Dashed lines* indicate the superimposed line of the opposing structure. The *arrow* represents the TT-TG distance

resonance imaging showed a TT-TG distance of 20 mm, with lateral patellar compression syndrome and extensive full-thickness cartilage loss throughout the lateral patellar facet and periphery of the lateral trochlea in a 10 × 15 mm area with subchondral marrow edema and cystic change (Fig. 9.2a, b). Even though there was no obvious tear identified involving the MPFL or patellar retinaculum, the degree of subluxation indicated MPFL attenuation or incompetence. The remaining structures of the knee appeared normal, although mild bursitis within the semimembranosus was identified.

Given the patients' findings of increased TT-TG distance, excessive patellar tilt and subluxation, and chondral wear of the lateral patellar facet, she was indicated for surgery consisting of anteromedialization osteotomy of the tibial tubercle, lateral retinacular release, MPFL reconstruction with hamstring autograft, and shaving chondroplasty of the patella.

Surgery

At the time of surgery, a diagnostic arthroscopy was performed, with confirmation of full-thickness cartilage loss on the lateral patellar facet and lateral trochlea. A shaving chondroplasty was performed, debriding the chondromalacia back to a stable rim (Fig. 9.3a, b). Next, the open portion of the procedure was initiated. An 8 cm incision along the medial patellar edge extending to the level of the tibial tubercle was placed. An open lateral retinacular release was performed, with care taken to protect the superior lateral geniculate artery. This was able to correct the excessive lateral patellar tilt. Next, attention was turned to the tibial tubercle osteotomy. A 45° angle of osteotomy was chosen, and the distal periosteum of the osteotomy was left intact to serve as a hinge point. A correction of 1 cm of medialization and 7 mm of anteriorization was achieved to reduce the TT-TG to a desired 10 mm. Provisional clamps were placed, and tracking was checked prior to placement of two 4.5 mm bicortical screws (Fig. 9.4). The final step involved MPFL reconstruction to address the patella subluxation. Gracilis autograft was harvested in the standard fashion and prepared on the back table. The proximal medial border of the patella was dissected, and two parallel 3.2 mm tunnels were drilled from the medial border to the anterior mid-patella to allow a looped passage of the gracilis graft, leaving the free ends for attachment in the femur. Schottle's point was identified at the junction between Blumenstadt's line and the posterior femoral condyles, along the posterior cortical line of the femur [16] (Fig. 9.5). A guide pin was placed at the MPFL origin. Isometry was then checked with the graft around the guide pin by taking the knee through a full range of motion.

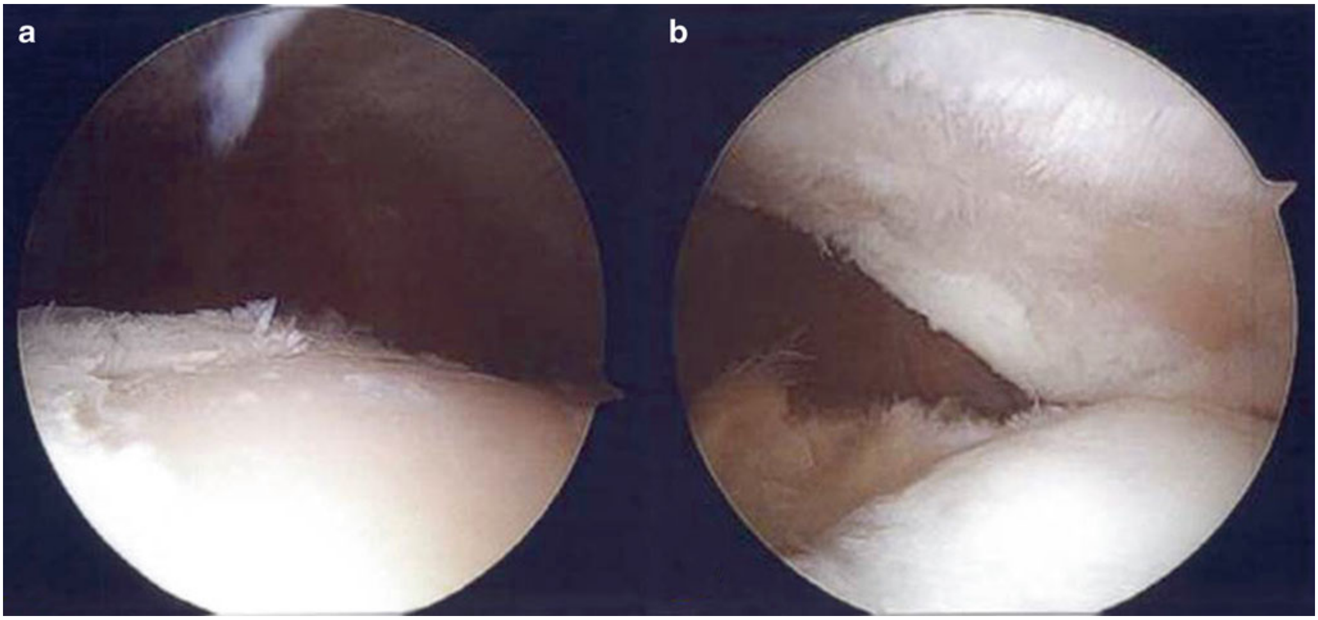

Fig. 9.3 Arthroscopic images showing full-thickness cartilage loss on both the lateral trochlea (**a**) and lateral patellar facet (**b**)

Fig. 9.4 Intraoperative fluoroscopy showing bicortical screw fixation of tibial tubercle osteotomy

Fig. 9.5 Lateral intraoperative radiograph showing Schottle's point, the junction between Blumenstadt's line and the posterior femoral condyles, along the posterior cortical line of the femur

After verification, final graft passage and interference screw femoral fixation was completed with the knee at 45° of flexion so that the patella was fully seated within the trochlear groove during tensioning.

Postoperatively, the patient was initially restricted to 50 % weight bearing until the osteotomy was healed (Fig. 9.6a–c). Flexion began at 0–60° and increased by 30° every 2 weeks in a hinged brace. She ultimately went on to heal uneventfully, although she continued to report occasional anterior knee pain and slight irritation related to the tibial tubercle screws, which required hardware removal at 15 months postoperative. Final radiographs prior to hardware removal are shown in Fig. 9.7a, b.

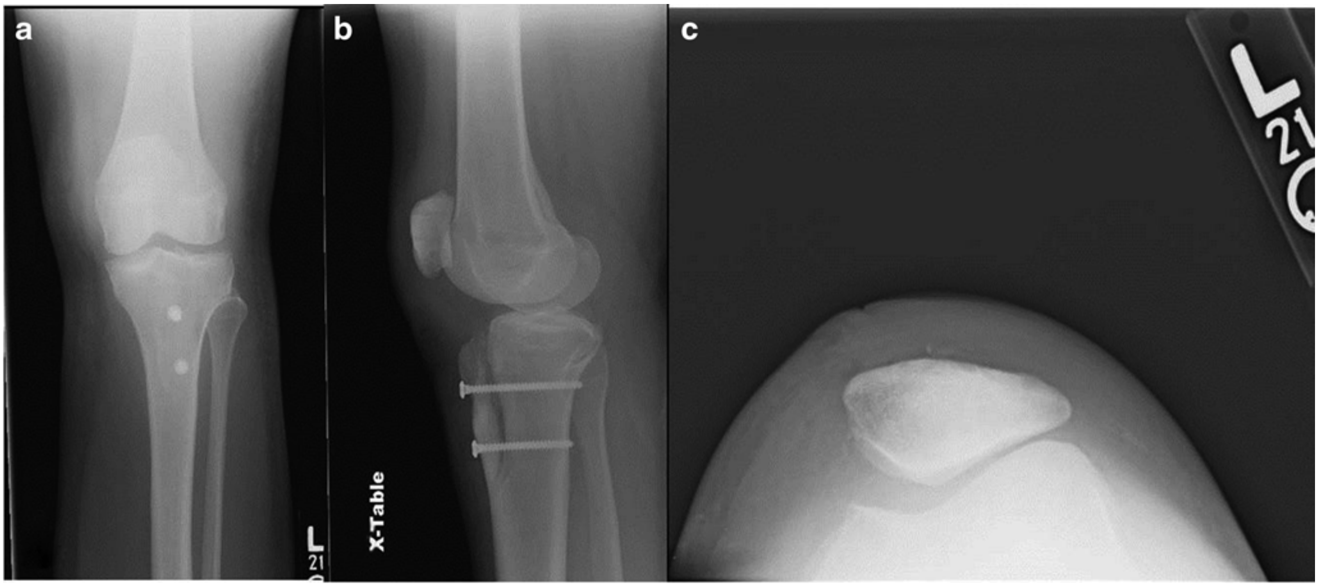

Fig. 9.6 Initial postoperative radiographs, showing fixation of the tibial tubercle (**a**, **b**) osteotomy and correction of excessive patellar tilt (**c**)

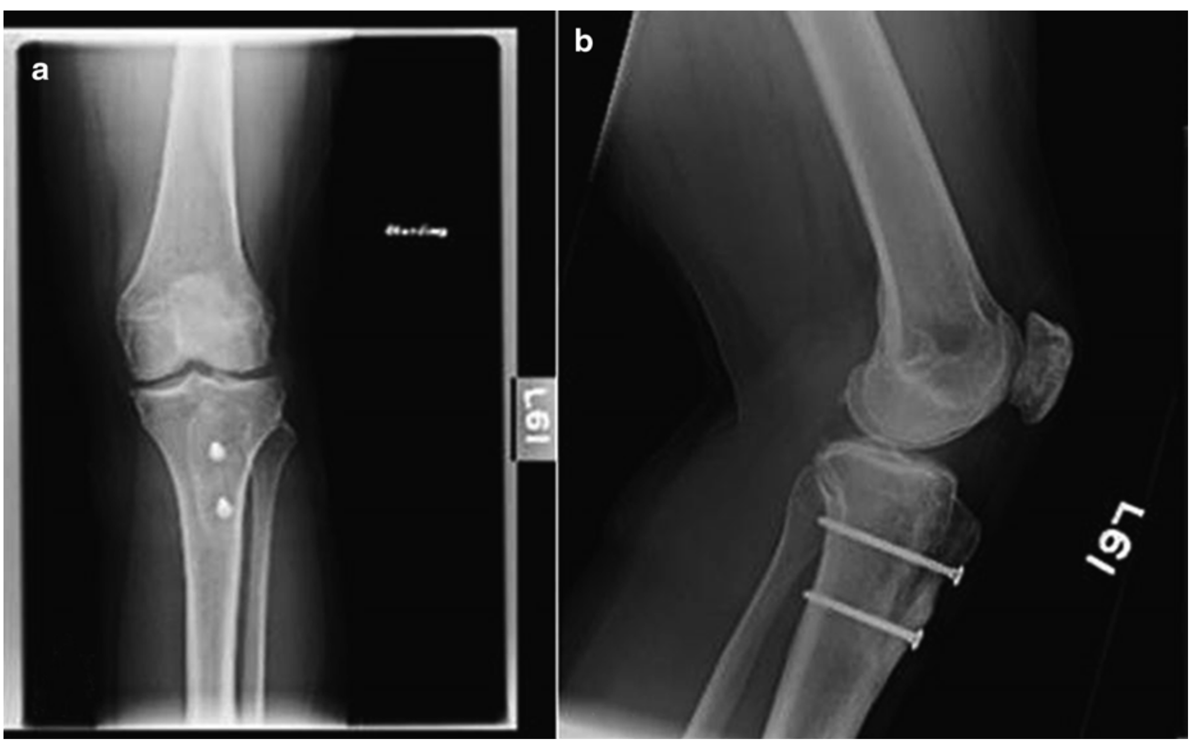

Fig. 9.7 (**a**, **b**) Final PA and lateral radiographs demonstrating a healed tibial tubercle osteotomy

Discussion

- General indications for combined proximal and distal procedures in patellar maltracking
- Essential steps for proper execution of tibial tubercle osteotomy, MPFL reconstruction

Case 2

History/Exam

A 13-year-old female presented to clinic with bilateral knee pain, left greater than right, since early childhood. There was no history of specific injury; however, the patient reportedly had subluxation of both kneecaps with every step, and pain was worsened by any prolonged activities. Prior to her presentation, she had received no operative treatment, but had failed a trial of physical therapy and activity modification. On initial examination, the patient was noted to have external rotation and valgus alignment of both her lower extremities. There was an effusion at the knees bilaterally, with patellar crepitus, tenderness, and apprehension. There was a markedly positive J sign with gross subluxation of the patella requiring manual reduction for the knee to flex. Essentially, her patellas dislocated constantly. The remaining examination findings were unremarkable.

Imaging

On initial imaging, the patient was noted to have a Caton–Deschamps ratio of 1.14 bilaterally, with severe trochlear dysplasia (Dejour type D) with a supratrochlear spur on the left and less severe on the right (Fig. 9.8a–d). There was evidence of MPFL insufficiency bilaterally, with patellar subluxation and excessive lateral tilt. The femoral tibial anatomic axis was 7°, and there was bowing of the femur and tibia resulting in mechanical axis displacement lateral to the joint center. A bilateral lower extremity computed tomography scan was ordered for surgical planning (Fig. 9.9a, b). On the left lower extremity, the femoral neck was retroverted 12° relative to the femoral condylar axis. There was marked trochlear dysplasia, with lateral subluxation and tilt. There was a chronic ossicle of the medial patella, suggestive of chronic avulsion injury from the patella. The TT-TG distance was 23 mm. On the right lower extremity, the femoral neck was retroverted 5°, with trochlear dysplasia and less severe lateral patellar subluxation and tilt. The TT-TG distance was measured at 28 mm. If desired, a 3D reconstruction CT scan can also be obtained for preoperative planning (Fig. 9.9c).

Based on the patients' findings of increased TT-TG distance, excessive patellar tilt, and severe trochlear dysplasia, she was indicated for surgery consisting of anteromedialization osteotomy of the tibial tubercle, lateral retinacular release, MPFL reconstruction with hamstring autograft, and sulcus deepening trochleaplasty. Since the left knee showed more severe symptoms at the time of her presentation, the decision was made for staged reconstruction starting with the left lower extremity. The patient did well clinically following her initial procedure and was indicated for her contralateral knee at 6 months postoperatively. The surgical sequence was similar, and to avoid redundancy, presented findings are based on the patient's second procedure only.

Surgery

On the patient's second procedure date, an examination under anesthesia was performed, confirming gross instability and maltracking of the right patella. Next, a standard medial parapatellar arthrotomy was placed. First, the tibial tubercle osteotomy was prepared, and a cut was made at 45°, leaving a distal periosteal hinge intact. Translation of 13 mm was achieved, based on the preoperative TT-TG distance of 28 mm to achieve a final distance of 15 mm, and the fragment was provisionally fixed with a clamp. Two bicortical 4.5 mm screws were placed after verifying correction of patellar tracking through a full range of motion.

Attention was then turned to the trochlea. After exposing the supratrochlear spur, which showed elevation approximately 1 cm off the anterior femoral cortex, the central trochlea was marked, and two additional markings for the planned osteotomy of the medial and lateral facets were placed (Fig. 9.10a). Alternatively, if a tubercle osteotomy is not performed, the TT-TG can also be improved by marking and creating a new trochlear groove lateral to the native groove, with the distance to the new groove at the proximal extent reflecting the improvement in the TT-TG distance. An osteotome was used to create a subchondral osteotomy around the superior borders of the trochlea, and a small oval burr was used to remove a portion of the bone deep to the subchondral shell to create a cavity (Fig. 9.10b). The bone was removed to the point that the shell would "trampoline" with moderate pressure and to the depth necessary to drop the deepest point of the new trochlear groove to be flushed with the anterior cortex of the femur. Next a #20 blade was used to cut the osteochondral shell along the medial and lateral facets and centrally within the trochlea. Suture anchor fixation was placed at the top of the notch (i.e., the base of the groove) and proximally over the proximal midpoint of each leaflet (Fig. 9.10c, d). A suture bridge with #2 Vicryl allowed the osteotomy to be held in the reduced position.

Next, attention was turned to harvest of the gracilis tendon for MPFL reconstruction. This was then taken to the

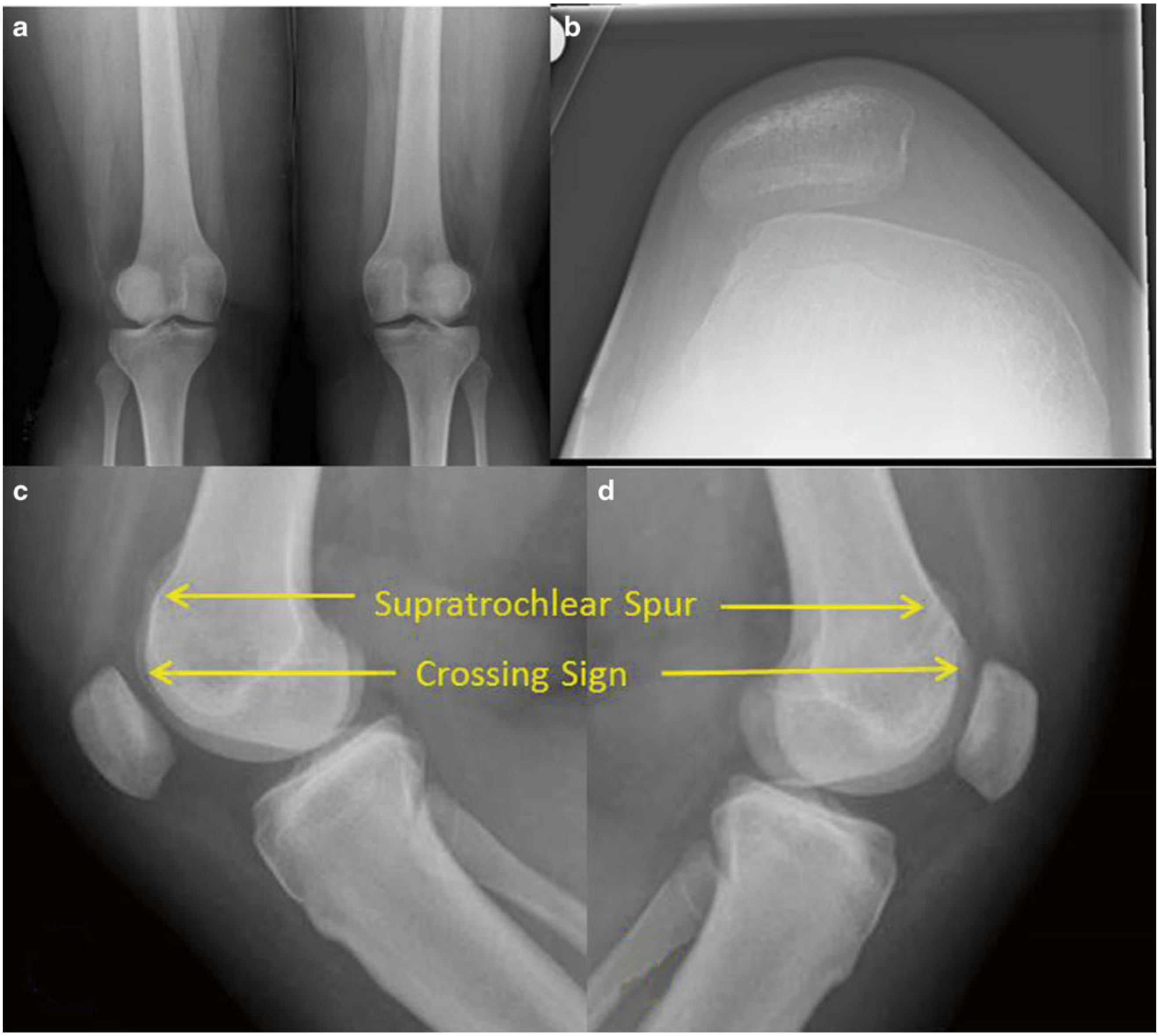

Fig. 9.8 (**a**–**d**) PA, merchant (R knee), and lateral radiographs, demonstrating Dejour type D trochlear dysplasia bilaterally (*arrows*), more severe on the left. The crossing sign represents the point at which the trochlea is flattened

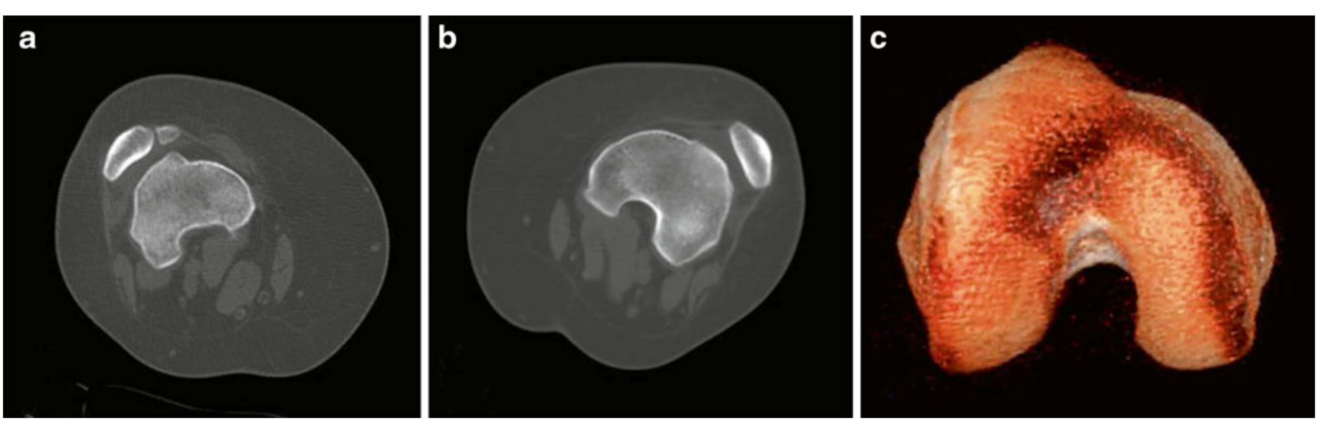

Fig. 9.9 (**a**) Right lower extremity CT showing a supratrochlear spur, patellar ossicle, and abnormal femoral rotation. (**b**) Left lower extremity CT showing a more severe rotational abnormality of the femur, with chronic patellar subluxation and trochlear dysplasia. (**c**) 3D reconstruction of CT scan for visualization of trochlear dysplasia

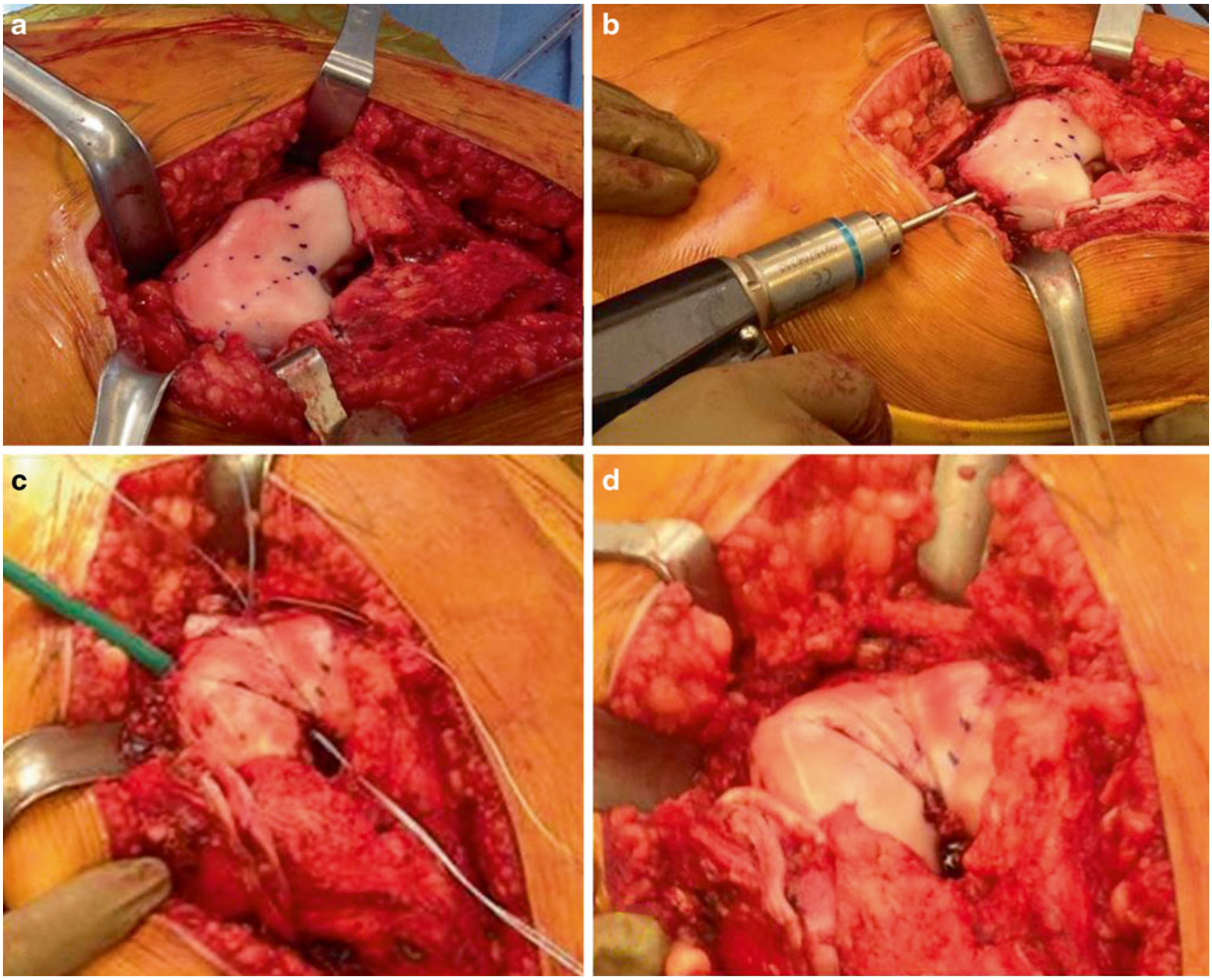

Fig. 9.10 (**a**) *Dotted lines* representing planned osteotomy sites. (**b**) Undermining of the bone deep to osteotomy with oval burr. (**c**) Placement of suture anchors in preparation for fixation of medial and lateral leaflets. (**d**) Final fixation of medial and lateral leaflets with #2 Vicryl sutures. Note improvement in the final depth of groove compared to A

back table for further preparation. After tendon harvesting, an open release of the lateral patellar retinaculum was completed, with care taken to avoid the superior lateral geniculate artery. MPFL reconstruction followed a similar sequence as is outlined in Case 1 (Fig. 9.11a, b). The medial patellar ossicle was excised.

Postoperatively, the patient was initially restricted to 50 % weight bearing until the osteotomy was healed (Fig. 9.12a–c). Flexion began at 0–60° and increased by 30° every 2 weeks in a hinged brace. On the right leg, postoperative range of motion had plateaued at 2 months postoperatively at 90°, and therefore, a manipulation under anesthesia was performed. Otherwise, the patient has progressed to uneventful healing bilaterally, with excellent reduction in pain and improved function.

Discussion

- Indications and technical considerations for performing trochleaplasty
- Surgical sequence for complex combined proximal and distal realignment procedures

Case 3

History/Exam

A 29-year-old female presented to clinic with long-standing right knee pain which was exacerbated following a motor vehicle crash. She previously was treated by another physician

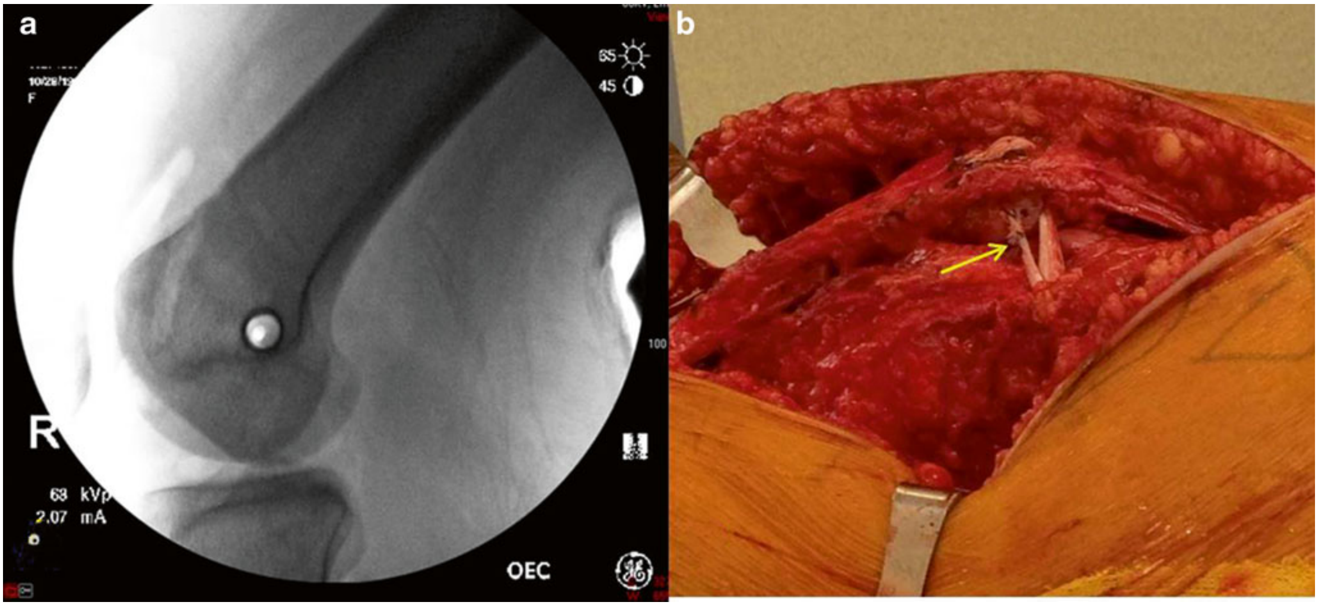

Fig. 9.11 (**a**) Schottle's point, for femoral tunnel entry in MPFL reconstruction. (**b**) Final graft in position for MPFL reconstruction (*arrow*)

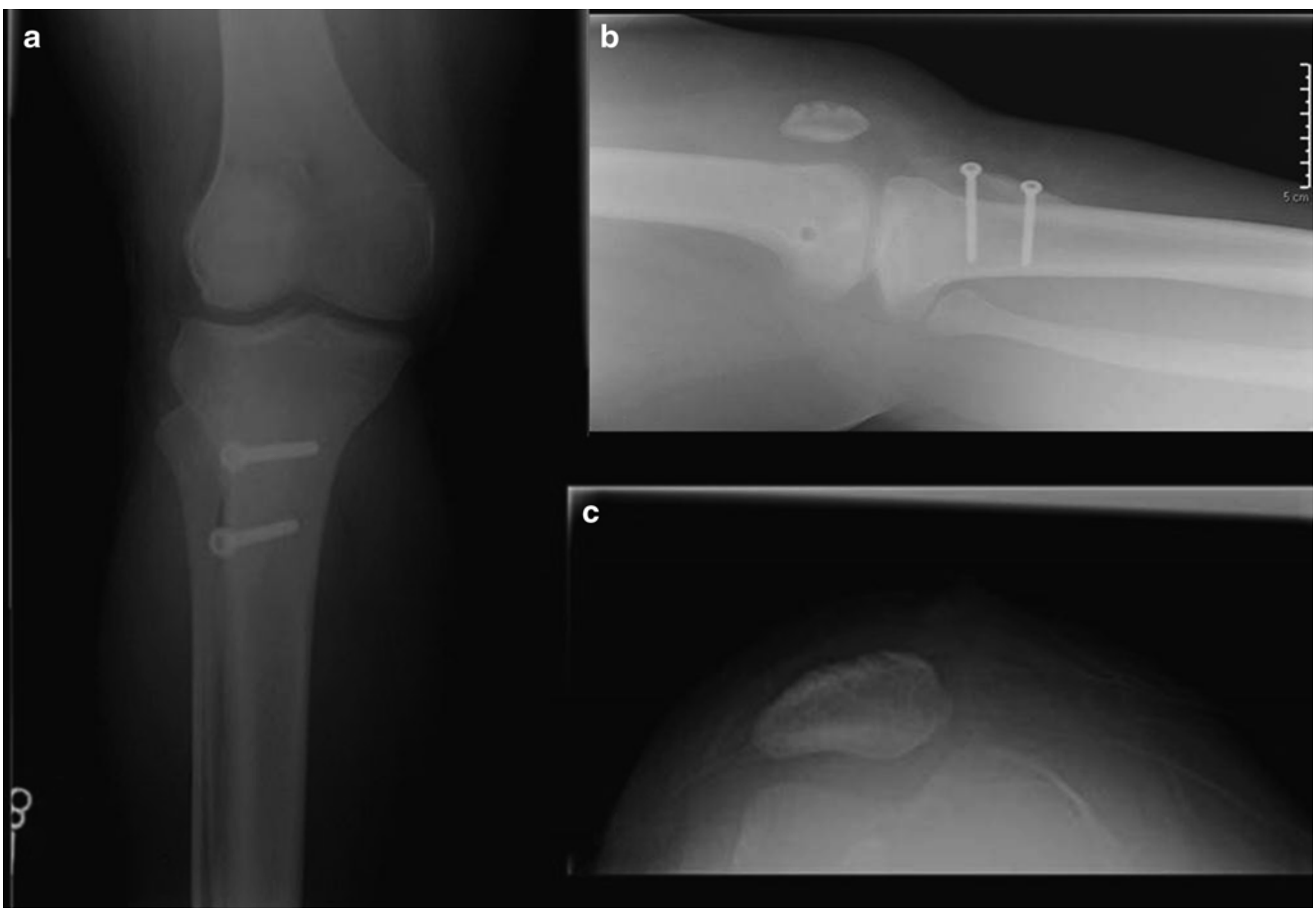

Fig. 9.12 (**a**–**c**) PA, lateral, and merchant views demonstrating tibial tubercle fixation and improvement in patellar tracking and tilt

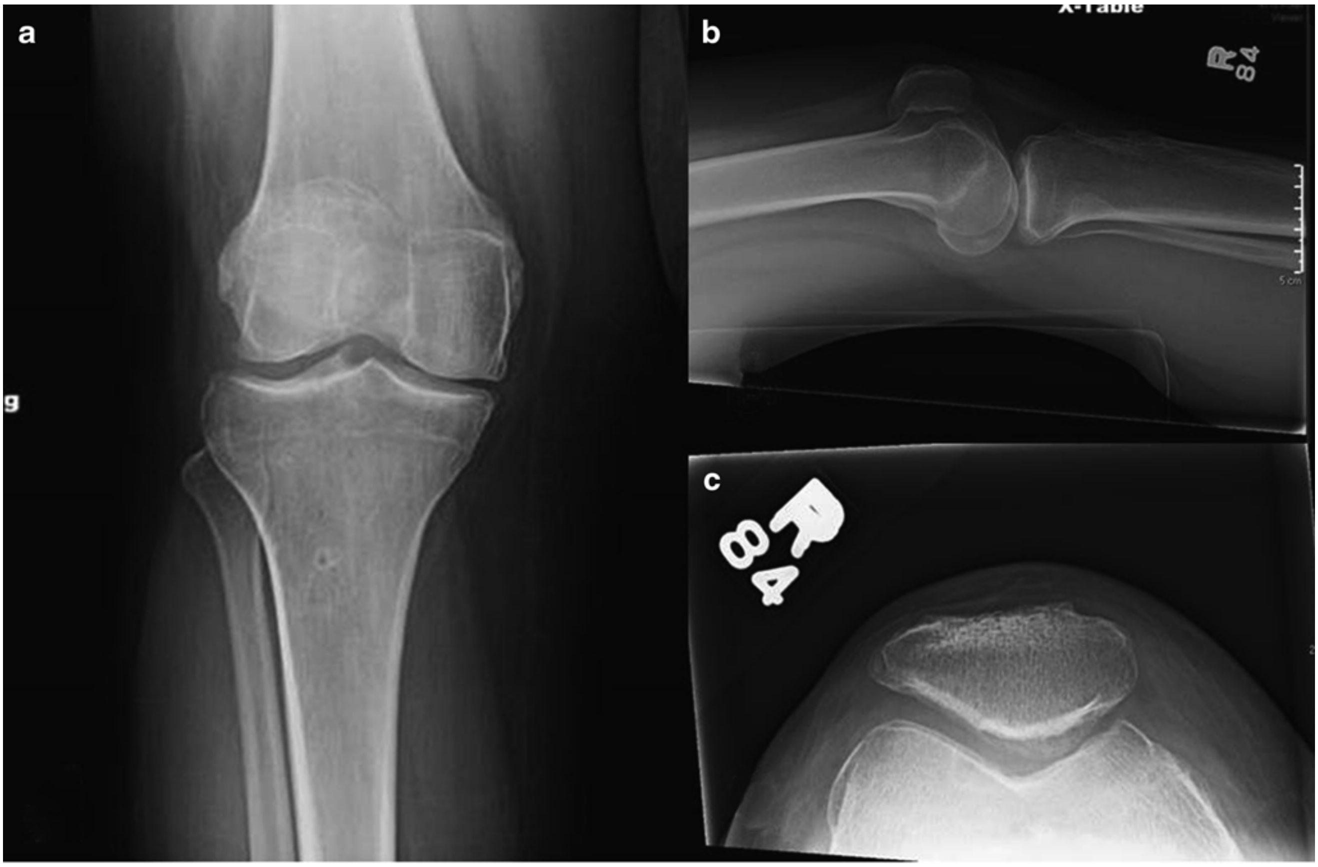

Fig. 9.13 (**a**–**c**) PA, lateral, and merchant views demonstrating normal patellar tracking, normal trochlear morphology, and healed osteotomy of the tibial tubercle

for multiple surgeries over a 3-year period. Initial surgery involved a plica excision, and subsequently she underwent lateral meniscus repair with proximal and distal extensor mechanism realignment. A third procedure involved the removal of previous hardware and a fourth a shaving chondroplasty of the patellofemoral joint. Her primary complaint upon presentation to our clinic was anterior knee pain, aggravated by stairs and activity. In addition to her multiple surgeries, the patient had failed nonoperative attempts with physical therapy, bracing, anti-inflammatories, steroid injections, and activity modification. On initial physical examination, there was significant patellar tenderness and crepitus, as well as a trace effusion. The patient also endorsed medial joint line tenderness and a positive McMurray. She did not have patellar apprehension, and her patella tracked normally. There was no lateral retinacular tightness, and there was a firm endpoint on MPFL testing. The remainder of her examination was remarkable only for generalized ligamentous laxity.

Imaging

Initial imaging included plain radiographs, which demonstrated mild joint line narrowing medially, with evidence of prior surgery and anteromedialization tibial tubercle osteotomy. The patellofemoral joint did not show evidence of maltracking or excessive tilt. Trochlear morphology appeared normal (Fig. 9.13a–c). MRI demonstrated evidence of postsurgical changes of the lateral meniscocapsular junction and full-thickness lesions of the proximal mid-patella and trochlea measuring 1.3 cm and 0.8 cm, respectively (Fig. 9.14a, b). The TT-TG distance was measured at 12 mm.

Based on her continued complaints of pain localized to the patellofemoral joint and her documented full-thickness cartilage loss, the patient was indicated for diagnostic arthroscopy with possible allograft cartilage transplantation with the particulated juvenile chondrocyte implantation technique.

Surgery

At the time of surgery, a diagnostic knee arthroscopy demonstrated Outerbridge grade IV cartilage loss over a 22×20 mm area of the patella, with a depth of 3 mm. On the trochlea, a 15×18 mm area was identified with Outerbridge grade IV cartilage loss, also at a 3 mm depth (Fig. 9.15a, b). There was mild degenerative change to the cartilage in the medial compartment, but no evidence of a medial meniscus tear. Next, a medial parapatellar arthrotomy was made, and the patella was partially everted. The patellar lesion and trochlear lesion were sharply

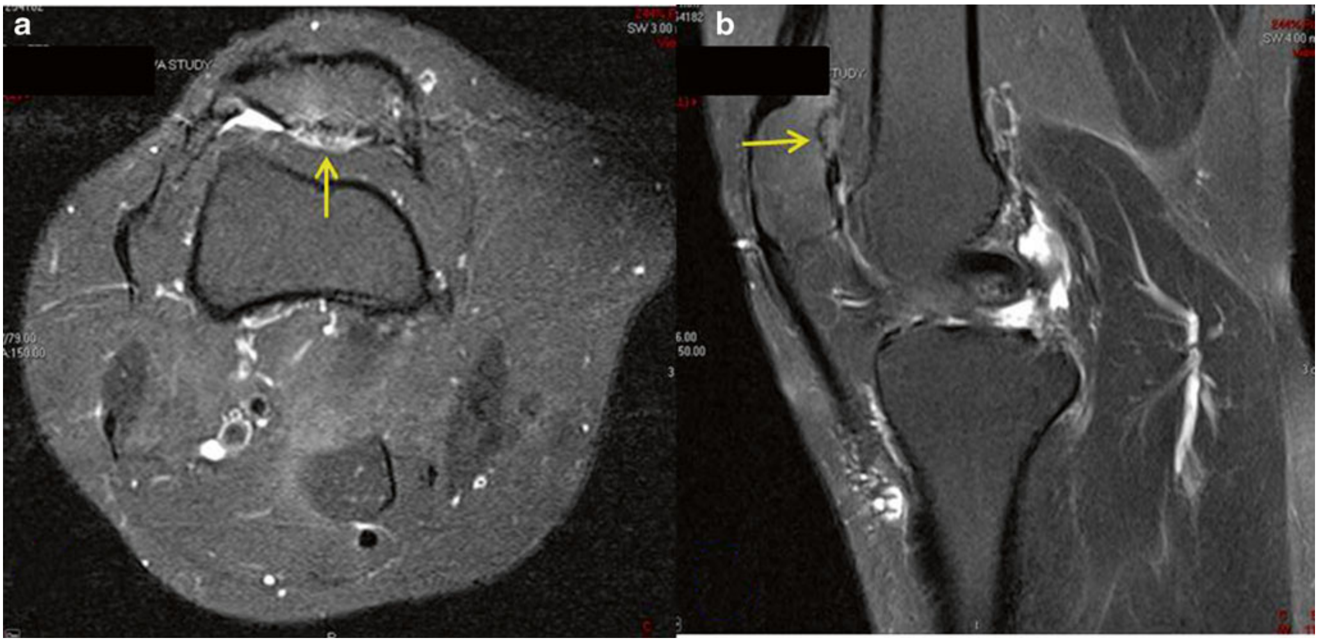

Fig. 9.14 (**a**, **b**) T2 imaging sequences demonstrating full-thickness cartilage defects of the proximal mid-patella and trochlea

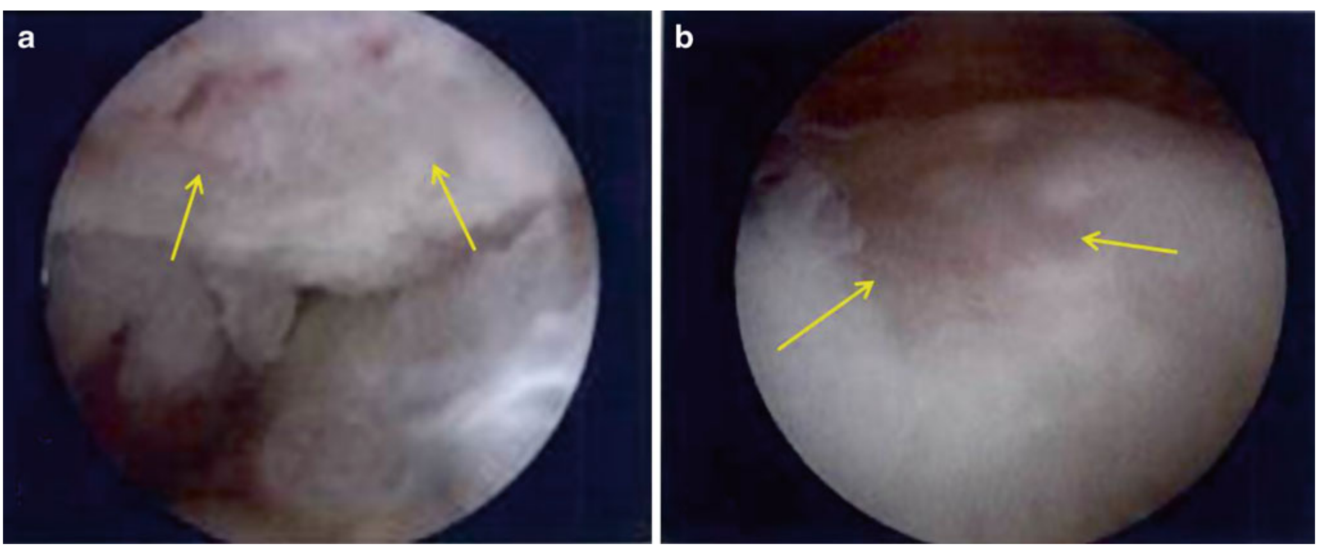

Fig. 9.15 Arthroscopic images confirming full-thickness cartilage loss of the mid-patella (**a**) and trochlear groove (**b**)

curetted to a stable rim of cartilage, and the particulated juvenile chondral implant was prepared on the back table (Fig. 9.16a). After placing a layer of fibrin glue at the base of the lesions, the minced chondral allograft was added and a final layer of fibrin glue placed on top (Fig. 9.16b, c). It is important to adhere closely to the manufacturer's recommendations regarding the timing of implantation/preparation of the graft and to monitor the density of the implanted cartilage, to avoid overgrowth.

In the initial postoperative phase, the patient was restricted to 25 % weight bearing and was placed in a hinged knee brace. She was gradually allowed to resume full weight bearing at 6 weeks. Range of motion was advanced as tolerated. At her most recent postoperative visit, she had regained full range of motion and has progressed with strengthening. Her pain level is significantly improved from the preoperative level.

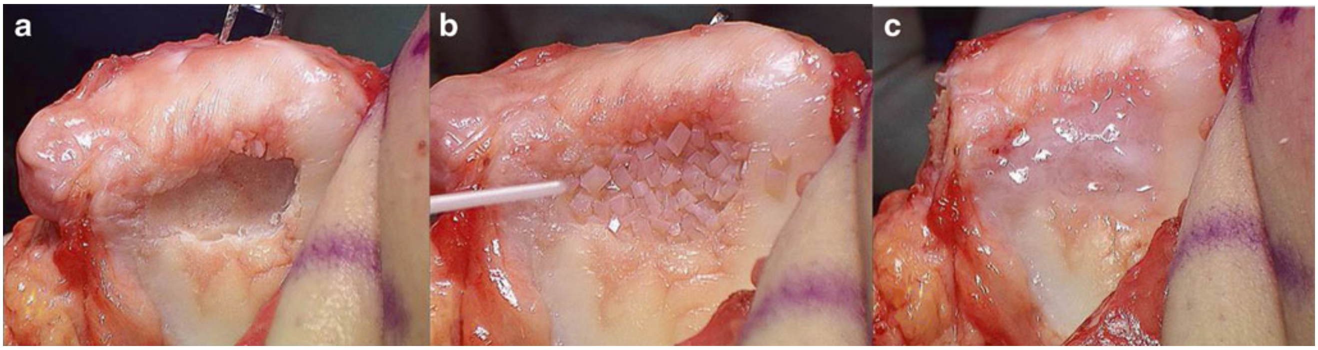

Fig. 9.16 (**a**) Patellar lesion curetted to stable rim. (**b**) Fibrin glue layer added to the base followed by minced chondral allograft. (**c**) The final layer of fibrin glue added over the top of minced chondral allograft

Discussion

- Strategies for management of full-thickness cartilage lesions of the patellofemoral joint
- Technical considerations for the use of allograft particulated juvenile chondrocytes

Conclusion

In the treatment of patellofemoral disorders, as demonstrated by each of the presented cases, it is essential to thoroughly correlate the radiographic findings to the patient's history and physical examination. This comprehensive approach offers the best chance of achieving successful outcomes, but in some cases, despite appropriate management, patients may continue to experience discomfort related to patellofemoral joint disorders. In these isolated cases, consideration of patellofemoral arthroplasty may be reasonable as a final alternative to total knee arthroplasty; however, it is important to set appropriate patient expectations prior to surgery. Patellofemoral arthroplasty may significantly delay additional surgeries, but for most patients is not viable as a definitive strategy, as may often be the case for the various other reconstructive procedures discussed.

References

1. Fithian DC, Paxton EW, Stone ML, Silva P, Davis DK, Elias DA, White LM. Epidemiology and natural history of acute patellar dislocation. Am J Sports Med. 2004;32:1114–21.
2. Hawkins RJ, Bell RH, Anisette G. Acute patellar dislocations. The natural history. Am J Sports Med. 1986;14:117–20.
3. Colvin AC, West RV. Patellar instability. J Bone Joint Surg Am. 2008;90:2751–62.
4. Dejour H, Walch G, Nove-Josserand L, Guier C. Factors of patellar instability: an anatomic radiographic study. Knee Surg Sports Traumatol Arthrosc. 1994;2:19–26.
5. Dejour D, Le Coultre B. Osteotomies in patello-femoral instabilities. Sports Med Arthrosc. 2007;15:40.
6. Berg EE, Mason SL, Lucas MJ. Patellar height ratios. A comparison of four measurement methods. Am J Sports Med. 1996;24:218–21.
7. Alemparte J, Ekdahl M, Burnier L, Hernández R, Cardemil A, Cielo R, Danilla S. Patellofemoral evaluation with radiographs and computed tomography scans in 60 knees of asymptomatic subjects. Arthroscopy. 2007;23(2):170–7.
8. Sanders TG, Morrison WB, Singleton BA, Miller MD, Cornum KG. Medial patellofemoral ligament injury following acute transient dislocation of the patella: MR findings with surgical correlation in 14 patients. J Comput Assist Tomogr. 2001;25:957–62.
9. Pihlajamäki HK, Kuikka PI, Leppänen VV, Kiuru MJ, Mattila VM. Reliability of clinical findings and magnetic resonance imaging for the diagnosis of chondromalacia patellae. J Bone Joint Surg Am. 2010;92(4):927–34.
10. Mäenpää H, Lehto MU. Patellar dislocation-the long term results of non-operative management in 100 patients. Am J Sports Med. 1997;25:213–7.
11. Stefancin JJ, Parker RD. First-time traumatic patellar dislocation. A systematic review. Clin Orthop Relat Res. 2007;455:93–101.
12. McConnell J. Rehabilitation and non-operative treatment of patellar instability. Sports Med Arthrosc. 2007;15:95–104.
13. Fulkerson JP. Diagnosis and treatment of patients with patellofemoral pain. Am J Sports Med. 2002;30(3):447–56.
14. Smith TO, Walker J, Russell N. Outcomes of medial patellofemoral ligament reconstruction for patellar instability. A systematic review. Knee Surg Sports Traumatol Arthrosc. 2007;15(11):1301–14.
15. Steiner TM, Torga-Spak R, Teitge RA. Medial patellofemoral ligament reconstruction in patients with lateral patellar instability and trochlear dysplasia. Am J Sports Med. 2006;34(8):1254–61.
16. Schöttle PB, Fucentese SF, Pfirrmann C, Bereiter H, Romero J. Trochleaplasty for patellar instability due to trochlear dysplasia. A minimum 2-year clinical and radiological follow-up of 19 knees. Acta Orthop. 2005;76(5):693–8.
17. Utting MR, Mulford JS, Eldridge JD. A prospective evaluation of trochleaplasty for the treatment of patellofemoral dislocation and instability. J Bone Joint Surg Br. 2008;90(2):180–5.
18. Schottle PB, Schell H, Duda G, Weiler A. Cartilage viability after trochleoplasty. Knee Surg Sports Traumatol Arthrosc. 2004;12:300–6.
19. Von Knoch F, Bohm T, Burgi ML, et al. Trochleaplasty for recurrent patellar dislocation in association with trochlear dysplasia. A 4 to 14-year follow-up study. J Bone Joint Surg Br. 2006;88:1331–5.