

Joint-Preserving Osteotomies for Isolated Patellofemoral Osteoarthritis: Alternatives to Arthroplasty

Vicente Sanchis-Alfonso, MD, PhD, and Jason L. Koh, MD, MBA

Abstract

Patellofemoral osteotomies can provide excellent symptomatic relief for selected patients with isolated patellofemoral osteoarthritis (PFOA). Isolated PFOA is a relatively common disorder, seen in 24% of women and 11% of men over the age of 55 years. In up to 89% of these patients, PFOA occurs at the lateral facet of the patella, and is especially amenable to surgical treatment. Particularly in younger patients, joint-preserving osteotomies can provide excellent and reliable relief while delaying the need for partial or joint arthroplasty and subsequent revision. These osteotomies, such as partial lateral patellar facetectomy (PLPF), patella-thinning osteotomy (PTO), tibial tubercle anteromedialization (AMZ) osteotomy, and sulcus-deepening trochleoplasty (SDT), are reviewed for indications, technique, and results. In particular, patients with primarily lateral facet or distal and lateral lesions have excellent outcomes with patellofemoral osteotomies.

Isolated patellofemoral osteoarthritis (PFOA) is a relatively common disorder. Based on radiological evidence, its prevalence is 24% in women and 11% in men aged over 55 years.¹ However, the presence of PFOA on radiographic images does not always correlate with clinical symptoms. PFOA is symptomatic in only 8% of women and 2% of men aged over 55 years,¹ and a mismatch often occurs between the symptoms and radiological severity

(**Figures 1A-1E**). In young patients, PFOA occurs at the lateral facet of the patella in 89% of the cases.² Patients with primarily lateral facet lesions can have excellent outcomes with osteotomy surgery.

PFOA surgery may be considered when nonsurgical treatment is ineffective and pain becomes disabling. However, which surgical treatment for isolated PFOA is optimal remains controversial. The largest setback in weighing nonarthroplasty surgical options for isolated PFOA is that few studies have been published. Furthermore, published studies offer little scientific evidence; they include case series with few patients and retrospective analyses with limited follow-up and no control group for comparison.

This article focuses on osteotomies, which are described in only 15 articles found through PubMed. The small number is logical given that the prevalence of symptomatic isolated PFOA is low¹ and that the majority of patients do not need surgical treatment. A complicating factor is that osteotomy is often associated with other surgical procedures, such as lateral retinaculum release. In descriptions of these cases, it is not clear if the outcome for PFOA is attributable to the osteotomy, is secondary to the associated procedure, or both.

Several alternatives to patellofemoral arthroplasty—partial

Take-Home Points

- Patellofemoral osteotomies can provide excellent and reliable symptomatic relief for many patients with symptomatic isolated PFOA.
- PLPF of 1 cm to 1.5 cm of lateral bone can provide excellent pain relief in patients with isolated lateral facet arthritis and overhanging osteophytes without diffuse chondromalacia or hypermobility.
- At 5-year follow-up, >80% of partial lateral facetectomy patients have symptomatic relief.
- Tibial tubercle AMZ (Fulkerson procedure) can provide excellent results in patients with distal and lateral patella chondropathy.
- Avoidance of overmedialization, early range of motion, and limited weight-bearing can help avoid complications associated with tibial tubercle AMZ.

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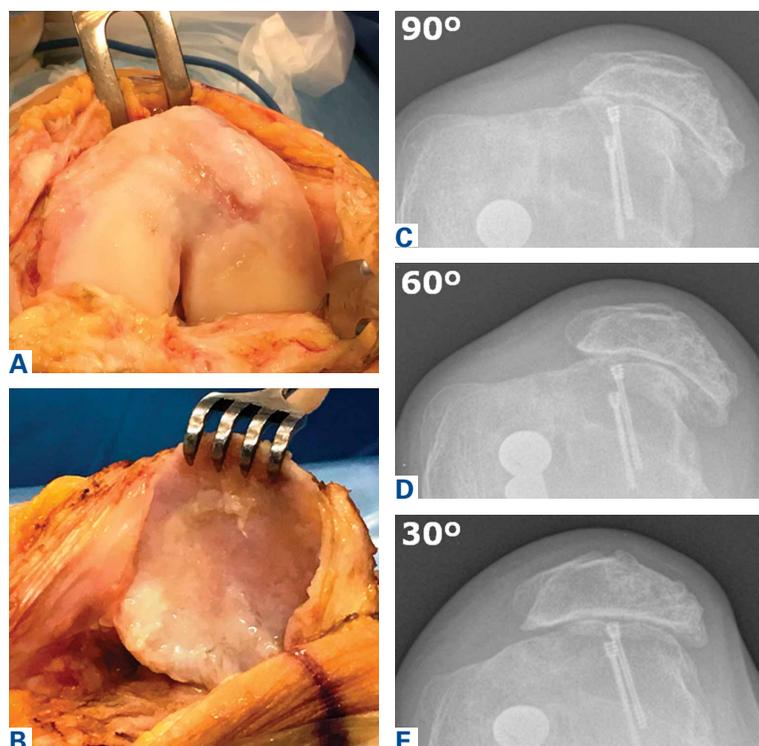


Figure 1. A 29-year-old woman who sought help due to severe left patellar instability. She had only a slight pain. (A) Severe trochlear dysplasia and severe osteoarthritis. (B) The patella has lost all the cartilage. (C, D, E) X-rays showing a severe patellofemoral osteoarthritis. The patella dislocates laterally with knee flexion.

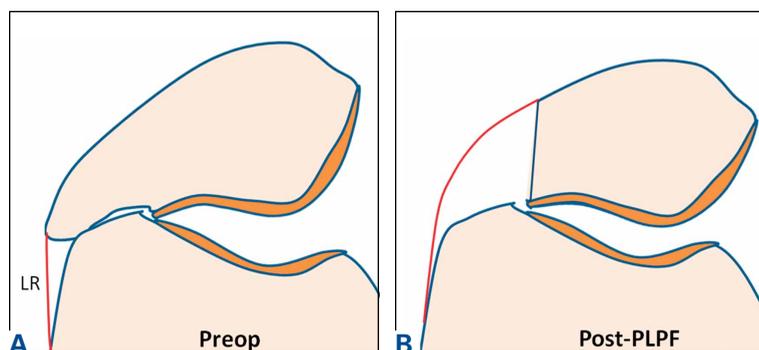


Figure 2. Diagram of partial lateral patellar facetectomy (PLPF). (A) Preoperative image. (B) Post-PLPF in a patient with isolated lateral patellofemoral osteoarthritis with full cartilage loss.

Abbreviations: LR, Lateral retinaculum.

lateral patellar facetectomy (PLPF), patella-thinning osteotomy (PTO), anteromedialization (AMZ), and sulcus-deepening trochleoplasty (SDT)—are available for the management of isolated PFOA. In this article, we analyze the value of each of these techniques in preserving the patellofemoral joint in the presence of PFOA. These techniques combine the US and European perspectives. The ultimate objective with these surgical techniques is to delay arthroplasty as long as possible.

Partial Lateral Patellar Facetectomy

PLPF is a relatively simple and effective surgical treatment for isolated PFOA in active middle-aged to elderly patients who want to maintain their activity level.^{3,6} Using an oscillating saw to resect 1 cm to 1.5 cm of the lateral facet of the patella reduces lateral retinaculum tension and thereby decreases lateral patellofemoral contact pressures (Figures 2A, 2B). PLPF is indicated in isolated lateral PFOA with full cartilage loss and lateral patellar osteophytes associated with localized lateral patellar tenderness, a negative passive patellar tilt test, excess lateral patellar tilt on radiographs, and normal patellofemoral tracking (tibial tubercle-trochlear groove [TT-TG] distance, <20 mm). The main contraindications are medial or diffuse patellar chondropathy and patellar hypermobility.

PLPF improves pain and function over the long-term and delays the need for major surgery. Wetzel and Bellemans⁵ evaluated 155 consecutive patients (168 knees) with mean post-PLPF follow-up of 10.9 years. By final follow-up, 62 knees (36.9%) had failed and been revised to total knee arthroplasty (TKA) (60 knees), patellofemoral arthroplasty (1 knee), or total patellectomy (1 knee). Mean time to reoperation was 8 years. Kaplan-Meier survival rates with reoperation as the endpoint were 85% at 5 years, 67.2% at 10 years, and 46.7% at 20 years. At final follow-up, 79 (74.5%) of the 106 knees that had not been revised were rated good or fair, which accounts for 47% of the original group of 168 knees. The key finding is that the effects of PLPF lasted through the 10-year follow-up in half of the patients.⁵ Paulos and colleagues⁴ found 5 years of symptomatic relief in more than 80% of carefully selected patients who did not have significant (grade IV) arthritis in the medial or lateral knee compartments.

PLPF is a safe, low-cost, and relatively minor surgery with a low morbidity rate and fast recovery. Also, it does not close the door on other surgery and can easily be converted to TKA. Wetzel and Bellemans⁵ found that 36.9% of reoperations were TKAs, and López-Franco and colleagues³ found that 30% of knees required secondary TKA.

Patella-Thinning Osteotomy

In patients who are under 65 years old and have disabling anterior knee pain recalcitrant to conservative treatment, PTO may be considered for isolated PFOA with any type of chondral lesion (including severe diffuse chondropathy with exposed bone) (Figures 3A-3C), patellofemoral joint

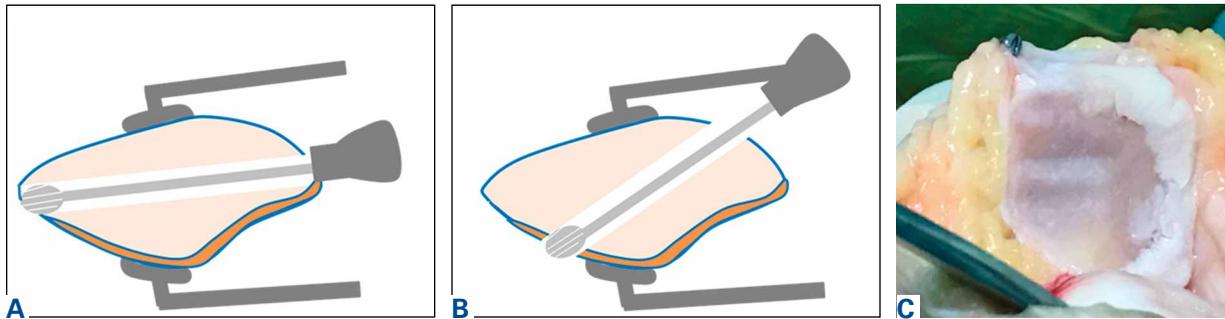


Figure 3. Diagram of patella-thinning osteotomy (PTO) using high-speed side-cutting burr. (A) The cutting plane must be strictly parallel to the anterior cortex of the patella. (B) Incorrect cutting plane. (C) In cases of isolated patellofemoral osteoarthritis, including very severe cases of articular damage at any location in the patella and a normal tracking, we could consider the PTO.

space reduced by more than 50% on skyline view, patellar thickness of 20 mm or more, and normal TT-TG distance.⁷ Vaquero and Arriaza⁸ found that thinning the patella by 7 mm significantly reduced patellofemoral joint reacting forces. Post-PTO improvement may be attributable to various factors, including decreased patellofemoral pressure and decreased intraosseous pressure. PTO is performed with a high-speed side-cutting burr while a plane is maintained strictly parallel to the anterior cortex of the patella (Figure 3A). When the PTO is completed, the surgeon tightens the clamp, collapses the central part of the patella, and fixes both fragments with biodegradable pins.

Vaquero and colleagues⁷ analyzed PTO outcomes in 31 patients (35 knees) with mean follow-up of 9 years and noted significant improvements in functional scores and radiologic parameters. All patients except 1 were satisfied with the operation. Radiologic progression of PFOA was slowed, but radiologic femorotibial osteoarthritis progressed in 23 cases (65%), and 4 required TKA. The authors found satisfactory clinical and radiologic outcomes—only 4 patients (12.5%) required TKA—and good functional outcomes.⁷

PTO, a low-morbidity surgery with good functional outcomes, does not close the door on other surgery, such as TKA.⁷

Tibial Tubercle Anteromedialization Osteotomy

Whereas PLPF and PTO are indicated in knees with normal TT-TG distance, Fulkerson AMZ osteotomy must be considered in isolated PFOA with articular cartilage lesions at the distal or lateral patellar facets resulting from long-standing malalignment with increased TT-TG distance (**Figures 4A, 4B**). In fact, Fulkerson tibial tubercle AMZ is advised in these cases.^{9,10}

AMZ unloads the distal and lateral facets of the patella while improving the extensor mechanism.^{11,12} A successful AMZ outcome requires

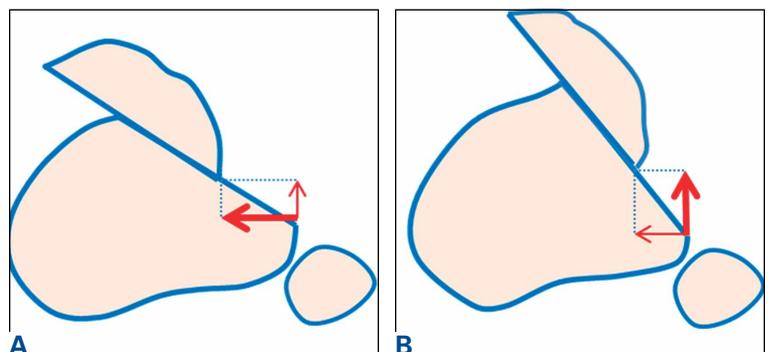


Figure 4. Obliquity of osteotomy plane determines degree of anterior and medial displacement of tibial tubercle. (A) The lesser the slope, the more medialization. (B) The bigger the slope of the osteotomy, the more anteriorization.

preservation of some of the medial and proximal articular cartilage of the patella. In 1983, Fulkerson¹³ described use of tibial tubercle AMZ osteotomy to address patellofemoral pain associated with patellofemoral chondrosis in conjunction with patellofemoral tilt and/or chronic patellar subluxation. This technique is indicated when the patella needs to be realigned for relief of elevated contact stress and centralization. Currently the technique is used not only in patients with isolated PFOA but in patients with chronic lateral patellar instability. Fulkerson osteotomy combines the benefits of the Maquet technique (unloading) and the Elmslie-Trillat technique (tracking improvement) in a single osteotomy, with no distraction of the osteotomy site with bone graft and without the complication rate of Maquet tibial tubercle elevation. Before surgery, computed tomography (CT) or magnetic resonance imaging (MRI) is routinely used to measure TT-TG distance to determine the tibial tubercle medialization required in the Fulkerson osteotomy. However, TT-TG distance must be used with caution, as it cannot be determined in cases with trochlear dysplasia. Consequently, physical examination and arthroscopic examination for evaluation

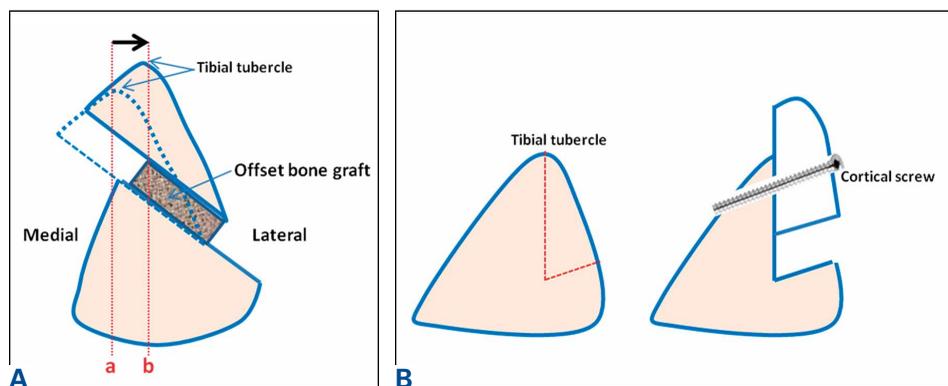


Figure 5. (A) Neutralized anteromedialization. Placing a bone graft in the osteotomy focus optimizes the anteriorization effect but decreases the medialization. (B) Anteriorization of the tibial tubercle by means of a sagittal plane osteotomy.

of patellofemoral tracking and location of chondral defects should be performed before the Fulkerson osteotomy.

Rationale; Indications and Contraindications; Preoperative Planning

As already noted, AMZ unloads the distal and lateral facets of the patella. Beck and colleagues¹⁴ suggested AMZ is appropriate for unloading the lateral trochlea. However, it is not useful for central chondral defects and may actually increase the load in patients with medial chondral defects. As AMZ shifts contact force to the medial trochlea, Fulkerson osteotomy is appropriate when distal and lateral chondral lesions must be unloaded. Because this procedure moves the tibial tubercle medially and anteriorly, loads are transferred to the proximal and medial facets of the patella. Therefore, the procedure is contraindicated when diffuse, proximal, or medial chondral lesions are present. Moreover, AMZ is contraindicated in patients with normal TT-TG distance because there is the risk that overmedialization will cause symptomatic medial subluxation. Grade III or IV central trochlear cartilage lesions are also less likely to have successful AMZ outcomes. Therefore, before Fulkerson osteotomy is performed, MRI should be obtained to evaluate the patellofemoral articular surface and TT-TG distance. MRI provides information that is useful for preoperative planning because it allows assessment of articular cartilage lesions, including their location and severity. Moreover, because the osseous and cartilaginous contours of the patella differ, MRI gives a more accurate picture of the patellofemoral congruence than CT does. Last, before the open surgery is performed, the patellofemoral joint should be arthroscopically examined to determine the location of chondral lesions. Cartilage lesion mapping is

important because Fulkerson osteotomy outcomes depend on chondral lesion location. Pidoriario and colleagues¹⁵ correlated AMZ outcomes with articular lesion location and noted optimal outcomes in patients with distal and lateral patellar articular lesions and intact trochlear cartilage (87% good and excellent outcomes). Patients with medial lesions and proximal or diffuse lesions generally did poorly (55% good and excellent

outcomes in medial lesions vs 20% good and excellent outcomes in proximal and diffuse lesions). Central trochlear lesions were associated with medial patellar lesions, and all patients with central trochlear lesions had poor outcomes. Interestingly, Outerbridge grading of patellar lesions was not significantly correlated with overall outcomes.¹⁵ Even in cases of severe chondropathy, including bone-on-bone arthritis, AMZ has had reliable outcomes and may be superior to arthroplasty because of joint preservation, duration up to 8 years, and restoration of patellofemoral tracking. It should be noted that a resurfacing technique such as patellofemoral arthroplasty is not a substitute for patella realignment. Any patellofemoral maltracking must be corrected before patellofemoral arthroplasty. Fulkerson osteotomy does not preclude subsequent surgery (eg, TKA). Furthermore, AMZ may prevent the natural progression of PFOA related to chronic lateral tracking.

AMZ osteotomy can be adjusted for the specific indication and for the location of chondral defects. If the primary goal is unloading a lateral lesion, or lateral maltracking, then a flatter osteotomy may be performed to increase the relative medialization of the tubercle; however, if the primary goal is unloading a distal lesion, then a relatively more oblique or vertical osteotomy may be performed to transfer the load more proximally. This is the technique preferred by authors in most cases in which more anteriorization is desired.

When TT-TG distance is used to guide surgical realignment, patellofemoral chondrosis associated with normal TT-TG distance can be addressed with directly anterior displacement of the tibial tubercle. Anteriorization of the tibial tubercle can be obtained by inserting a bone block between the tubercle and the tibial cut (Figure 5A).¹⁶ The medialization can be neutralized by making this block as



Table. **Pearls and Pitfalls: Anteromedialization**

Reconstruction Stage	Pitfalls	Pearls
Arthroscopy of patellofemoral joint	Patients with medial (type III) lesions and proximal or diffuse (type IV) lesions generally had poor outcomes, and all patients with central trochlear lesions had poor outcomes ¹⁵	Performing arthroscopy of patellofemoral joint before osteotomy helps determine the most appropriate approach for realignment so normal tracking is restored without adding load to any lesion ^{11,15,26}
	Anteromedialization (AMZ) is contraindicated in patients with normal tibial tubercle to trochlear groove (TT-TG) distance (<15 mm) and in patients with associated medial, proximal, or diffuse patellar lesions (AMZ shifts load to medial and proximal areas of patella); in addition, AMZ outcomes are less likely to be successful in patients with grade III or IV central trochlear cartilage lesions	Outcomes were optimal in patients with distal (type I) and lateral (type II) patellar articular lesions and intact trochlear cartilage Excessive TT-TG distance can be used as indication for distal realignment procedure
Exposure	Medial and lateral borders of tibial attachment of patellar tendon are not carefully released with scissors	Blunt retractor is placed at lateral tibial wall to protect anterior compartment muscles, anterior tibial vessels, and deep peroneal nerve, which lie anterior to interosseous membrane
Osteotomy	Passing posterior to intramuscular septum; maximum cut angle is ~60°	Obliquity of osteotomy plane can be adjusted to change amount of medial and anterior transfers of tibial tubercle. More vertical osteotomy results in more anterior transfer of tubercle for given amount of translation; flatter osteotomy results in more medial transfer ^{27,28}
Temporary fixation and assessment of realignment	Overmedialization can occur and result in substantial morbidity Treating proximal laxity with distal realignment alone	Patellar tracking should be carefully assessed during procedure to avoid undercorrection or overcorrection; patella should start slightly lateral and smoothly enter trochlea without sudden movement or abnormal medial-to-lateral motion
Tibial tubercle fixation	Great care is not taken when posterior cortex is penetrated	Knee is flexed to 90° to let posterior vascular structures fall away from posterior tibial cortex

the measured medialization.¹⁶ Another option is sagittal plane osteotomy (**Figure 5B**).

Surgical Outcomes of Anteromedialization in Patellofemoral Osteoarthritis

Fulkerson and colleagues¹⁰ followed 30 patients for more than 2 years after they underwent AMZ of the tibial tubercle for persistent patellofemoral pain associated with patellar articular degeneration. Of these 30 patients, 12 were followed for more than 5 years. The authors reported 93% good and excellent subjective outcomes and 89% good and excellent objective outcomes. Quality of improvement was sustained for all 12 patients reevaluated more than 5 years after surgery. When examined separately, 75% of patients with advanced PFOA had a good outcome, but none had an excellent outcome. Carofino and Fulkerson¹⁷ retrospectively evaluated tibial tubercle AMZ for isolated PFOA in 22 knees (17 active patients older than 50 years at time of surgery; mean age, 55 years) with minimum follow-up of 2 years (mean, 77 months). Mean postoperative Lysholm score was 83. According to Lysholm scores, outcomes were good to excellent in 12 cases, fair in 6, and poor in 1. The authors concluded that tibial tubercle AMZ is a de-

finite treatment option for isolated PFOA in active older patients. Morshuis and colleagues¹⁸ retrospectively evaluated 22 patients (25 knees) who underwent Fulkerson osteotomy for patellofemoral pain. Outcomes were evaluated a mean of 12 and 30 months after surgery. At the first evaluation, 84% of patients had satisfactory outcomes, and, at the second (≤38 months after surgery), 70%. Only in relatively young patients without signs of PFOA did outcomes remain satisfactory in all cases. At the later evaluation, 60% of patients with PFOA and/or lateralization had satisfactory outcomes.

Tips and Tricks to Avoid Complications

For some patients, AMZ performed technically correctly produced unhappiness—an outcome that may arise from incorrect patient selection or failure to meet patient expectations. It is important to discuss objectives and expectations with the patient before surgery. With correct patient selection and meticulous surgical technique (with customization of osteotomy angle and translation based on underlying lesion), surgeons have obtained excellent outcomes with infrequent complications (**Table**). Cutting guides or sequential drill bit placement can help reduce the variability of the angle cut of the

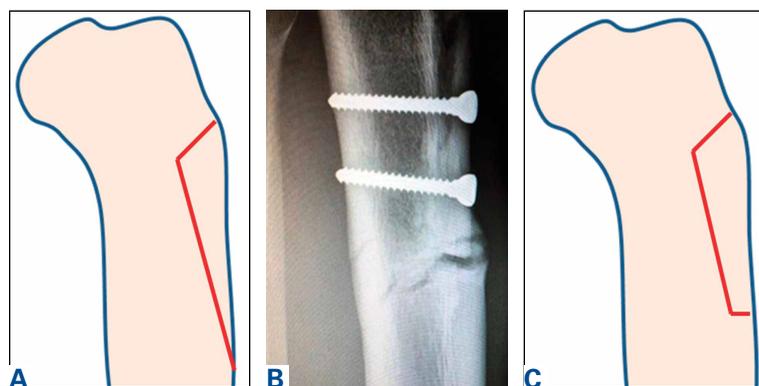


Figure 6. (A) Tapered osteotomy. (B) Tibial fracture after Fulkerson osteotomy. (C) Notched osteotomy. “Notched osteotomy” must be avoided, and distal cut tapered anteriorly.

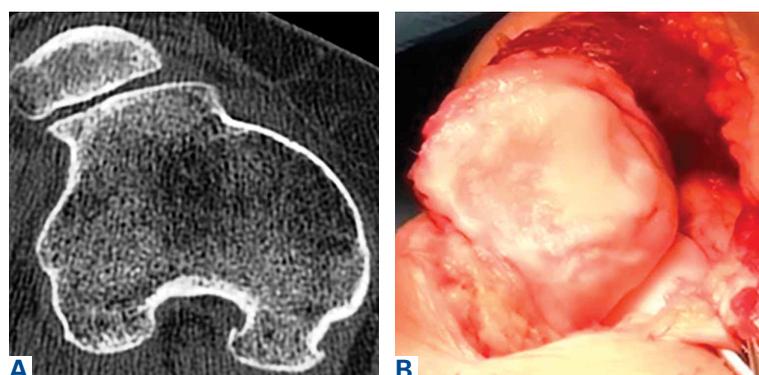


Figure 7. (A) Computed tomography shows severe trochlear dysplasia. (B) Patellofemoral osteoarthritis in setting of chronic lateral patellar instability. Patient presented with disabling anterior knee pain and severe lateral patellar instability. Pain was completely resolved after sulcus-deepening trochleoplasty associated with reconstruction of medial patellofemoral ligament.

osteotomy.

Intraoperative complications may involve neurovascular structures. The anterior tibial artery and the peroneal nerve are at risk during Fulkerson osteotomy. Decreased anterior sensation related to the infrapatellar branch of the saphenous nerve is not uncommon. Reducing the risk of neurovascular injury requires use of retractors and keeping the saw blade visible at all times. Another potential devastating complication is injury of the posterior vascular structures during bicortical tibial drilling for screw placement. According to Kline and colleagues,¹⁹ bicortical drilling may occur precariously near the posterior vascular structures of the knee. They advised extreme caution in drilling the posterior cortex during this procedure. To avoid the risk of compartment syndrome, surgeons can leave the anterior compartment fascia open or pie crust it by making multiple small perforations to decrease tension. Tibial fracture is another potential complication with this osteotomy. Reducing the risk of fracture involves tapering the distal cut

anteriorly and avoiding a “notched” osteotomy (**Figures 6A-6C**). Before definitive fixation of the osteotomy, patellar tracking must be evaluated to avoid overmedialization. If a “clunk” from extension to flexion is noted, iatrogenic medial instability should be suspected. The goal would be TT-TG distance of 10 mm to 15 mm. Commonly, if 4.5-mm bicortical screws are used, patients will have persistent pain or discomfort on direct palpation of the screw heads, and in some cases screw removal is required. This problem can be minimized with use of smaller (3.5-mm) countersunk screws or headless screws. Post-AMZ fractures of the proximal tibia have occurred on initiation of full weight-bearing or on too early return to activity.²⁰ Patients should be advanced gradually to partial weight-bearing, and be allowed full weight-bearing only after the osteotomy shows radiographic evidence of complete healing. Fulkerson²¹ advised prescribing protected weight-bearing with crutches for 6 to 8 weeks and discouraged running for 6 months and competitive sports for 9 to 12 months. Nonunion of the tibial tubercle has been reported²² but is relatively uncommon and can be treated with a reduction in physical activity and use of a bone growth stimulator. Excessive anterior tubercle translation resulting in skin breakdown typically does not occur with AMZ surgery.

Postoperative complications, which are similar to those associated with any knee surgery, include infection, arthrofibrosis, complex regional pain syndrome, thromboembolism, nonunion, fixation failure, and fracture. Arthrofibrosis has many causes, but the problem decreases with secure osteotomy fixation, early knee motion, and patellar mobilization. Overmedialization can result in medial patella instability, typically subluxation rather than complete dislocation. The instability can be relatively subtle or can cause pain and weakness. Lateralization of the tibial tubercle might be appropriate.²³

Sulcus-Deepening Trochleoplasty

High-grade trochlear dysplasia with a prominence, frequently present in lateral patellar instability, is thought to correlate with PFOA because it produces an anti-Maquet effect.²⁴ The dysplasia provokes an increment of the patellofemoral joint pressure that could explain patellofemoral chondropathy and ultimately PFOA. In fact, 33% of patients with isolated PFOA have a history of objective patellar dislocation.²⁴ In these cases, SDT could be considered. Several studies have examined use of this technique in the treatment of instability,

but not PFOA.²⁵ After SDT, pain resolves despite the chondral lesions being left alone (**Figures 7A, 7B**). Removing the bump improves patellofemoral congruence and kinematics and reduces the patellofemoral joint reaction force; that is, overloaded areas are unloaded. SDT increases the space between the patella and the femoral trochlea and thereby reduces patellofemoral joint pressure, essentially producing a Maquet effect. These findings raise the question of whether articular cartilage is essential in the patellofemoral joint. In other words, does the patellofemoral joint really need replacing? In the patellofemoral joint, patellofemoral congruence and smooth kinematics appear to be much more important than normal articular cartilage.

Conclusion

Patellofemoral joint replacement is an option for patellofemoral pain only in very select cases. Preserving the joint is always a primary goal. As not all PFOA cases are equal, joint-preserving surgery must be tailored to the patient. The keys to success are good indication, precise surgery, proper rehabilitation, and, above all, doing only what is needed.

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