MIS Patellofemoral Arthroplasty: Onlay Technique

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Jess H. Lonner and Andrew I.U. Longenecker

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J.H. Lonner (✉) • A.I.U. Longenecker
Rothman Institute, Sidney Kimmel Medical College at Thomas Jefferson University, Philadelphia, PA, USA
e-mail: jess.lonner@rothmaninstitute.com

Epidemiological studies show that isolated patellofemoral arthritis may occur in as many as 9 % of patients over the age of 40 and in 15 % of patients 60 and older [1]. Symptomatic patellofemoral chondromalacia occurs with even greater frequency and is a very common reason for presentation for orthopedic evaluation, particularly in women between the ages of 30 and 50 years. Women were more than twice as likely as males to have isolated patellofemoral arthritis (24 % vs. 11 %) in one study [2]. This gender predilection is undoubtedly related to the often subtle patellar malalignment and dysplasia that is common in women. Nearly half of the patients who present for surgical treatment of patellofemoral arthritis are 50 years old or younger [3].

Patellofemoral arthroplasty is an option for the treatment of isolated patellofemoral arthritis and recalcitrant grade IV patellofemoral chondromalacia. The traditional nonarthroplasty surgical alternatives for PF arthritis, long recognized for their shortcomings and limited short-term success, are losing ground to this increasingly more popular treatment method. The pain relief resulting from patellofemoral arthroplasty (PFA) is superior to other patellofemoral-specific treatment strategies, like patellectomy and tibial tubercle-unloading procedures. Total knee arthroplasty (TKA) can be effective for patients with PF arthritis; however, it may not be optimal for the younger demographic of patients considering surgical treatment [4, 5]. Additionally, enthusiasm for patellofemoral arthroplasty

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continues to increase as newer designs with improved features emerge, surgical indications are refined, and techniques and instrumentation improve. Furthermore, revision to total knee arthroplasty is not compromised after PFA, making it a reasonable intermediate procedure in young and middle-aged patients with isolated patellofemoral arthritis [6].

Selecting an implant of sound design is important to optimize the ultimate results, but surgical technique, namely accurate implantation of the components and balancing the soft tissues, is paramount. Like unicompartmental knee arthroplasty (UKA), PFA lends itself naturally to minimally invasive approaches. It is important, however, since this is a newer treatment alternative for most, to first familiarize oneself with the nuances of the procedure through a more extensile approach and then reduce the incision length and arthrotomy more gradually. Formerly, designs and implant systems either required completely freehanded techniques or instruments that were so large and bulky that extensile incisions and arthrotomies were necessary. Now, instrumented minimally invasive PFA is possible because of refinements in instrumentation (Gender Solutions PFJ, Zimmer, Warsaw Indiana) or introduction of precision freehand robotic technologies (Navio, Smith and Nephew, Memphis TN).

This chapter discusses the role of PFA for isolated patellofemoral arthritis, describes an instrumented MIS surgical technique for an onlay-style trochlear component, and reviews the results of the procedure.

Indications and Contraindications

Patellofemoral arthroplasty may be considered in the treatment algorithm for patients with localized patellofemoral osteoarthritis, posttraumatic arthritis, or grade IV bipolar (involving both the patella and the trochlea) or unipolar (involving either the patella or the trochlea) chondromalacia. Slight patellar tilt is not contraindications for this procedure; in such cases, a lateral retinacular release or recession may be necessary at the time of arthroplasty. PFA is appropriate for patellofemoral arthritis in the presence of dysplasia; it should be avoided in patients with considerable patellar maltracking or malalignment, unless these conditions are correctable during or prior to PFA. Excessive Q angles should be corrected with tibial tubercle realignment before or simultaneous with PFA. The procedure should not be performed in patients with inflammatory arthritis or chondrocalcinosis involving the menisci or tibiofemoral chondral surfaces, nor should it be offered to patients with diffuse pain [7, 8]. Tibiofemoral arthritis or grade III or IV chondromalacia are contraindications to PFA, although recent work suggests a role for concomitant PFA and biological condylar resurfacing or unicompartmental knee arthroplasty when there is focal grade IV chondromalacia on the weight-bearing condylar surfaces noted in addition to the patellofemoral wear [9, 10].

The presence of medial or lateral joint line pain suggests more diffuse chondral disease and should be considered contraindications to isolated patellofemoral resurfacing. Patients with inappropriate expectations and those with unusually excessive pain requiring narcotics may not be suitable candidates. Flexion contractures and limited range of motion are contraindications because they subject the patellofemoral articulation to excessive loads and are indicative of knee pathology that extends beyond the patellofemoral compartment. While there are intuitive concerns, there are no data available on whether obesity or cruciate ligament insufficiency put the PFA at risk for failure. There is no upper age limit for PFA provided the other criteria are met [3, 8, 11].

Clinical Evaluation

History and Physical Examination

Taking a detailed history and performing a thorough physical examination of the patient under consideration for patellofemoral arthroplasty are necessary to corroborate that the pain is, in fact, localized to the anterior compartment of the knee and that it emanates from the patellofemoral chondral surfaces and not from soft tissues (such as the patellar or quadriceps tendons or pes anserinus bursa) or other remote sites, such as the lumbar spine or ipsilateral hip.

The history should include questions about whether there was prior trauma to the knee, patellar dislocation, or other patellofemoral "problems." A history of recurrent atraumatic patellar dislocations may suggest considerable malalignment, which may need to be corrected before patellofemoral arthroplasty. Pain should characteristically be directly retropatellar, or just lateral or medial to the patella, and is often exacerbated by activities that load the patellofemoral compartment, such as stair climbing and descent, ambulating on hills, standing from a seated position, sitting with the knee flexed, and squatting. There is typically much less or even no pain when walking on level ground. Medial or lateral joint line pain is not typical in truly isolated patellofemoral arthritis. A description of anterior crepitus is common.

The physical examination will often note pain on patella inhibition and compression, patellofemoral crepitus, and retropatellar knee pain with active and passive flexion. The presence of medial or lateral tibiofemoral joint line tenderness is concerning for the possibility of more diffuse chondral disease (even in the presence of relatively normal radiographs) and may be a contraindication to patellofemoral arthroplasty. Patellar tracking and the Q angle must be assessed, since maltracking and malalignment can compromise the outcomes after patellofemoral arthroplasty.

Imaging Studies

Standing anteroposterior and midflexion posteroanterior radiographs are critical to identify tibiofemoral arthritis. Supine coronal radiographs should be avoided because they may underestimate the presence or extent of tibiofemoral disease. Mild squaring-off of the femoral condyles and even small marginal osteophytes are not contraindications for patellofemoral arthroplasty if the patient has no tibiofemoral pain with activities and on physical exam, and if there is less than grade III chondral degeneration noted during arthroscopy or arthrotomy. Lateral X-rays occasionally demonstrate patellofemoral narrowing and osteophytes, but, particularly in younger patients, there may be minimal radiographic findings; the lateral X-rays can show whether there is patella alta or baja. Axial radiographs will demonstrate the position of the patella within the trochlear groove and the extent of arthritis, but, again, the radiographs may underestimate the extent of patellofemoral cartilage damage. Often subchondral sclerosis and facet "flattening" may be the only radiographic clues (Fig. 1a–d). Magnetic resonance imaging (MRI) is recommended for evaluating patellofemoral arthritis, but is particularly useful to rule out early tibiofemoral arthritis. Photographs from prior arthroscopic treatment will provide valuable information regarding the extent of anterior compartment arthritis and the status of the tibiofemoral articular cartilage and menisci.

Surgical Technique

Like all procedures, first developing a comfort level and proficiency with a procedure and instrumentation through a more extensile arthrotomy is absolutely paramount before transitioning to minimally invasive techniques. Patellofemoral arthroplasty is unforgiving; errors in alignment and soft tissue balancing can be deleterious to the outcomes. To be clear, no surgeon should struggle with a minimally invasive approach at the expense of ensuring that the critical tenets of patellofemoral arthroplasty are fulfilled – namely, component alignment, soft tissue balance, implant fixation, and avoidance of damage to structures which are not being resurfaced.

The typical skin incision will extend from just proximal to the medial aspect of the proximal edge of the patella (in flexion) to the joint line, just medial and proximal to the tibial tubercle (Fig. 2). As with all MIS approaches to the knee, the incision should be lengthened liberally if the skin edges become compromised or if there is unnecessary technical difficulty arising from the small incision or arthrotomy. Any of the MIS

Fig. 1 (**a**–**d**) Weight-bearing anteroposterior, midflexion posteroanterior, lateral, and axial radiographs demonstrating advanced patellofemoral arthritis with sparing of the tibiofemoral compartments. Note slight patellar tilt and subluxation

surgical arthrotomies can be utilized for PFA – medial parapatellar, midvastus, or subvastus – depending on the surgeon's preferences. In the senior author's experience, there is no difference in recovery or outcomes; therefore, a mini medial parapatellar or mini-midvastus arthrotomy is used for most cases. During arthrotomy, it is essential to avoid cutting normal articular cartilage or the menisci. Before proceeding with patellofemoral arthroplasty, carefully inspect the entire joint to make sure the tibiofemoral compartments are free of gross cartilage degeneration.

With MIS approaches to patellofemoral arthroplasty, most of the procedure is performed with the knee either in full extension (patellar preparation) or alternating between 20° and 60° of flexion for trochlear preparation, depending on whether the anterior or posterior part of the trochlea is being prepared, respectively. This is generally done with the patella subluxed laterally and everted to 90° (Fig. 3). The trochlear component should be externally rotated perpendicular to the anteroposterior (AP) axis of the femur to enhance patellar tracking (Fig. 4a). An intramedullary

Fig. 2 Typical skin incision for MIS approach to patellofemoral arthroplasty

Fig. 3 The patella is everted with knee nearly fully extended

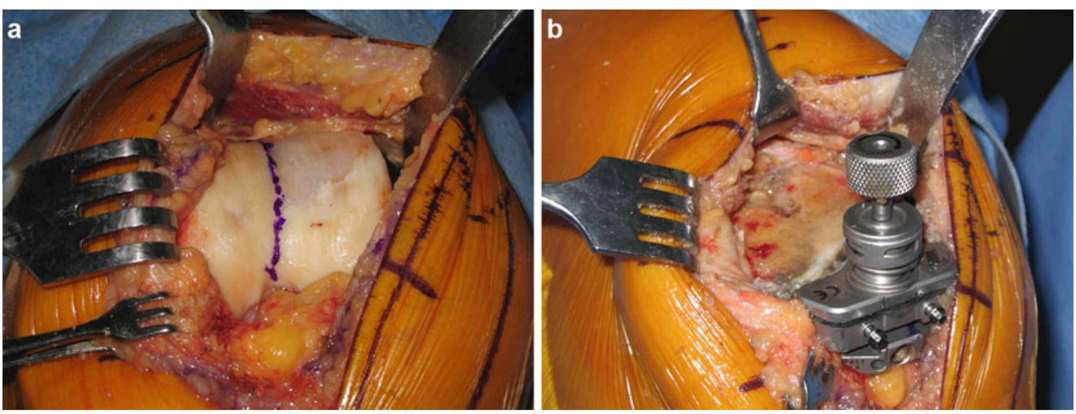

Fig. 4 (**a**) A line parallel to the anteroposterior axis (*Whiteside's Line*). (**b**) The cutting block is placed perpendicular to Whiteside's line. The cut is made flush with the anterior surface of the femoral cortex revealing the so-called baby grand piano sign

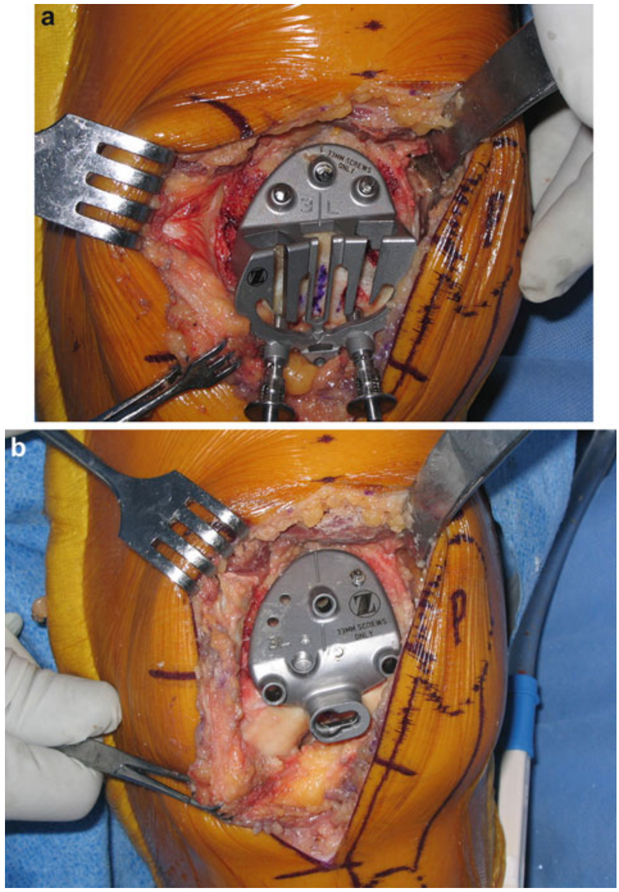

Fig. 5 (**a**) Preparation of the intercondylar surface of the trochlea is done with the milling guide, which also serves as a sizing template. (**b**) The template is positioned and lug holes drilled. The transitional edges are flush with the condylar cartilage

cutting guide is used, and the anterior resection is made perpendicular to the AP axis and flush with the anterior surface of the femur while the knee is midflexed between 30° and 60°. The classic baby grand piano sign should be sought (Fig. 4b).

The trochlear component size is selected so that neither its anterior surface nor transitional (intercondylar) edges overhang into the soft tissues. In the system utilized, a milling guide is used to prepare the intercondylar surface of the trochlea, the lugs holes drilled, and trialing performed. The intercondylar (transitional) edges should be flush with the adjacent condylar cartilage or inset 1–2 mm, but never proud relative to the articular cartilage (Fig. 5a, b).

The objective of patella resurfacing is to restore the original patella thickness and medialize the component, resecting 8–10 mm from the articular surface, parallel to the anterior patellar surface. Part of the fat pad should be removed for exposure and to eliminate potential sources of impingement. The exposed cut surface of the lateral patella that is not covered by the patellar prosthesis should be beveled or removed to reduce the potentially painful articulation on the trochlear prosthesis in extension and midflexion and on the lateral femoral condyle in deeper flexion (Fig. 6a–c) [12].

Assessment of patellar tracking is performed with the trial components in place, paying particular attention to identify patellar tilt, subluxation, or catching of the components (Fig. 7a). Patellar tilt and mild subluxation usually can be addressed successfully by performing a lateral retinacular recession or release, unless there is considerable extensor mechanism malalignment, which needs to be addressed with either tibial tubercle realignment (if the Q angle is excessive) or a proximal

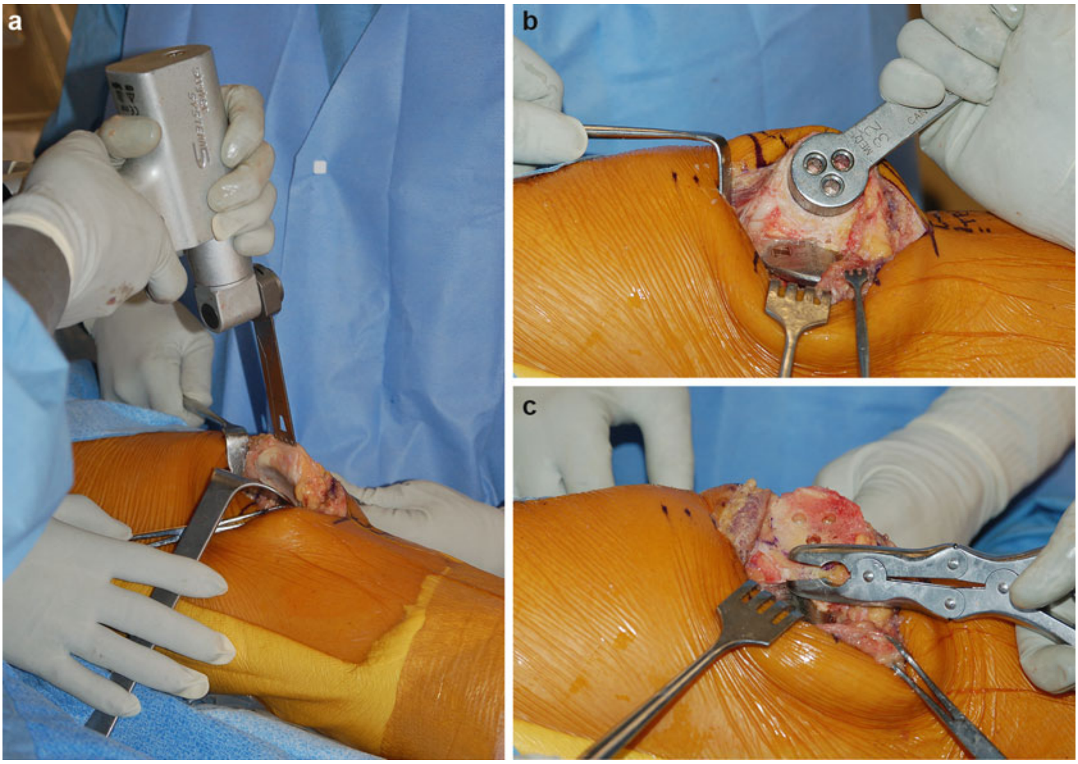

Fig. 6 (**a**–**c**) Patella preparation is performed with knee fully extended, and patella held vertically for resection (**a**). The drill guide is medialized (**b**), and the uncovered lateral facet is chamfered (**c**)

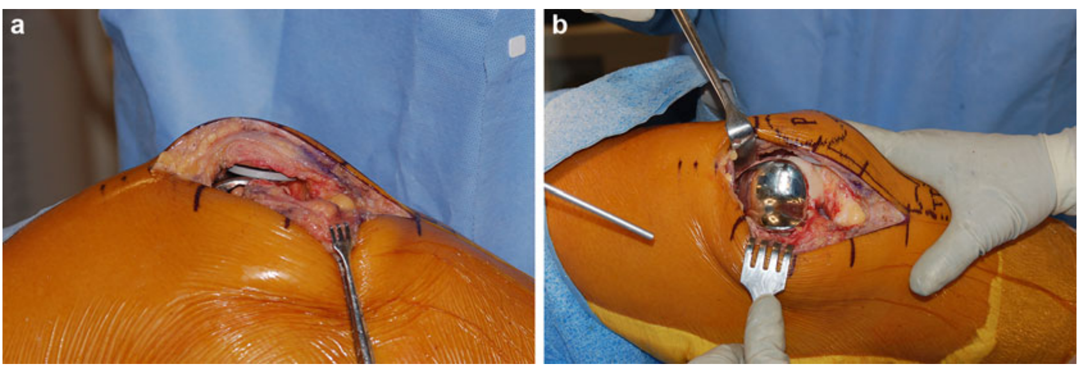

Fig. 7 (**a**, **b**) Patellar tracking is assessed with the trials in place (**a**) and then the components are cemented (**b**)

realignment. In the absence of a high Q angle, patellar maltracking with the trials in place is concerning for the possibility of component malposition (particularly internal rotation) and is more common with inlay than onlay trochlear components. The components can then be cemented into place, removing extruded cement while it cures (Fig. 7b).

Perioperative Management

For most patients, PFA is performed on an outpatient basis at either a surgery center or a hospital. Successful implementation of outpatient PFA requires dedicated preoperative preparation, medical risk stratification, patient expectation management and education, scheduling of postoperative physical therapy, a support network for the patient by family and friends, and prescription provisions for venous thromboembolism prophylaxis, antibiotics and pain management.

Minimization of intraoperative sedation with low-dose spinal anesthesia, preoperative nausea control and intra operative fluid management are paramount to secure early discharge. If all this is in place, the standard patient will be discharged several hours after surgery, with higher risk patients staying 23 h or occasionally overnight depending on circumstances.

Patients are encouraged to ambulate immediately with crutches, walker, or cane, with range-of-motion exercises initiated immediately. Formal outpatient physical therapy should be commenced within 2–5 days of surgery, and the use of a cane can be stopped once the patient has adequate balance and strength.

Effective postoperative pain management is one of the most important factors contributing to a successful operation and outcome. With well-controlled pain, patients are more comfortable going home the same day, are better able to participate in physical therapy, and consequently resume independent, unassisted ambulation. Perioperative protocols are re-evaluated periodically but currently consist of the following multimodal analgesia approach:

Preoperative Medication

- Celecoxib 200 mg daily starting 2 days before surgery.
- Oxycontin 10 mg in the morning of surgery.
- Within 2 h of surgery, patients are given "TLC": Tylenol (acetaminophen) 975 mg, Lyrica (pregabalin) 75 mg, and celecoxib 400 mg.

Intraoperative Medications

- Spinal anesthesia with low-dose bupivacaine (7.5–10 mg). Indwelling catheters, epidural anesthesia, and postoperative patient-controlled analgesia (PCA) are avoided
- Pericapsular injections. Currently 40 mL of 0.5 % ropivacaine or a combination of 30 mL of 0.5 % plain bupivacaine and 266 mg of liposomal-based bupivacaine diluted in 40 mL of 0.9 % saline are used – a comparative study is currently being done.
- Tranexamic acid administered intravenously (IV) using weight-adjusted dosing
- Patients are kept well hydrated during surgery.

Postoperative Medications

- While in the postanesthesia care unit (PACU), the goal is to avoid overuse of IV medications and narcotics. I prescribe acetaminophen 650 mg every 6 h (starting 12 h after first dose); pregabalin 75 mg every 12 h (avoid in patients over age 80); and Toradol 30 mg IV every 5 h (modify dose to 15 mg IV for elderly patients). For breakthrough pain, oxycodone IR 10 mg every 4 h and Tramadol 50 mg every 6 h can be given orally as needed.
- Patients are discharged on Percocet 5/325 mg every 4–6 h as needed
- A compressive cold wrap with freezable gel packs is encouraged as an effective adjuvant to oral pain medications.
- Zofran 4 mg 1–2 pills every 6–8 h as needed for nausea
- VTE prophylaxis for 4–6 weeks. Although there are various regimens, standard risk patients are adequately protected with enteric-coated aspirin 325 mg twice a day with Protonix 40 mg daily. In higher risk patients, low-molecular weight heparin 30 mg twice daily 12–24 h after surgery is injected.
- Antibiotic coverage. For patients discharged to home on the same day, oral antibiotic such as Keflex 500 mg or ciprofloxacin 500 mg is taken every 8 h for 3 doses.

Clinical Results

No studies have focused specifically on how the various surgical approaches impact the results of PFA. Nonetheless, collectively MIS techniques accelerate recovery and reduce early postoperative pain compared with older approaches in PFA. Recently, a prospective study of 70 PFA's with a third-generation onlay-style trochlear design implanted using MIS techniques was published.

Table 1 Clinical results of inlay-style patellofemoral arthroplasty

Series (y)	Implant	No. of PFAs	Age in years (range)	Duration of follow-up in years (range)	% of Good/ excellent results	% Revised
Blazina et al. [14]	Richards types I and II	57	39 (19–81)	2 (0.6–3.5)	NA	35
Krajca and Coker [18]	Richards types I and II	16	64 (42–84)	5.8 (2–18)	88	6
Arciero and Toomey [19]	Richards types I and II (14); CFS-wright (11)	25	62 (33–86)	5.3 (3–9)	85	28
De Winter et al. [15]	Richards types I and II	26	59 (22–90)	11 (1–20)	76	19
Kooijman et al. [20]	Richards types I and II	45	50 (20–77)	17 (15–21)	86	22
van Jonbergen et al. [21]	Richards types I and II	185	52 (NA)	13.3 (2–30.6)	NA	25
Cartier et al. [13]	Richards types I and II	72	65 (23–89)	4 (2–12)	85	7
Cartier et al. [22]	Richards types I and II	79	60 (36–81)	10 (6–16)	77	25
Argenson et al. [23]	Auctocentric	66	57 (19–82)	5.5 (2–10)	84	15
Argenson et al. [24]	Auctocentric	66	57 (21–82)	16 (12–20)	NA	42
van Wagenberg et al. [25]	Auctocentric	24	63 (31–81)	4.8 (2–11)	30	29
Tauro et al. [17]	Lubinus	62	66 (50–87)	7.5 (5–10)	45	28
Smith et al. [26]	Lubinus	45	72 (42–86)	4 (0.5–7.5)	69	19
Lonner [7]	Lubinus	30	38 (34–51)	4 (2–6)	84	33
Merchant [27]	Low contact stress	15	49 (30–81)	3.8 (2.3–5.5)	93	0
Charalambous et al. [28]	Low contact stress	51	64 (47–87)	2.1 (0.4–5)	33	33
Sisto and Sarin [29]	Kinematch	25	45 (23–51)	6 (2.6–10)	100	0

At a minimum 2-year follow-up (mean, 4.9 years), the mean range of motion was significantly improved from 124° to 138° postoperatively ($p < 0.0001$). Knee Society Knee and Function scores improved significantly ($p < 0.0001$), and less than 4 % of patients required revision arthroplasty for progressive tibiofemoral arthritis. There was no radiographic evidence of component loosening or wear and no clinical or radiographic evidence of patellar instability [3].

Results of patellofemoral arthroplasty are impacted by component position and alignment, soft tissue balance, quadriceps angle and patellofemoral alignment, implant design, indications for surgery, and presence and extent of tibiofemoral chondromalacia. Patellar instability, resulting from soft tissue imbalance, component malposition, or extensor mechanism malalignment, is the major source of short- and mid-term failure in patellofemoral arthroplasty and a prominent source of residual anterior knee pain [7, 13–17]. Results of both inlay-style and onlay-style implants are shown in Tables 1 and 2, respectively.

Table 2 Clinical results of onlay-style patellofemoral arthroplasty

Series (y)	Implant	No. of PFAs	Age in years (range)	Duration of follow-up in years (range)	% of Good/ excellent results	% Revised
Lonner [7]	Avon troch Nexgen Patella	25	44 (28–59)	0.5 (0.1–1)	96	0
Ackroyd et al. [16]	Avon	109	68 (46–86)	5.2 (5–8)	80	3.6
Starks et al. [30]	Avon	37	66 (30–82)	2 (NA)	86	0
Gao et al. [31]	Avon	11	54 (46–74)	2 (0.5–4)	100	0
Odumenya et al. [32]	Avon	50	66 (42–88)	5.3 (2.1–10.2)	NA	4
Mont et al. [33]	Avon	43	29 (27–67)	7 (4–8)	NA	12
Beitzel et al. [34]	Journey PFJ	22	46 (26–67)	2 (NA)	NA	4.5
Akhbari et al. [35]	Avon	61	66 (NA)	5 (1–10)	80	6.6
Kazarian et al. [3]	Gender solutions	70	51 (36–80)	4.9 (2.3–7.4)	NA	4

One series has highlighted the impact of trochlear implant shape and rotation on the incidence of patellofemoral-related problems [7]. Contemporary onlay designs have substantially reduced the incidence of patellofemoral complications [7, 16, 30, 31, 36]. Overall, satisfactory results were noted in 84 % of patellofemoral arthroplasties, but the incidence of patellofemoral dysfunction, including subluxation, catching, and substantial pain, was 17 % with a first-generation inlay trochlear prosthesis and less than 4 % with a third-generation onlay trochlear component [7]. Likewise, the Australian National Registry reported a 10 % revision rate for onlay-style designs compared to 20 % for inlay-style designs [37]. This is undoubtedly due to a lower incidence of patellar maltracking, typically less than 1 %, found in onlay-style trochlear designs for reasons described above [16, 30, 33, 36]. There is an anatomical explanation for the higher incidence of patellar maltracking with inlay components. Kamath and colleagues [38] examined trochlear inclination angles in 329 MRIs in patients with normal or dysplastic patellofemoral anatomy. They found that both groups had average trochlear inclination angles of 11.4° and of 9.4° internal rotation, respectively. This finding explains the propensity to internally malrotate inlay-style trochlear components, which predisposes to patellar maltracking and subluxation in as many as 17–36 % of cases [7, 14, 15, 17]. Revising an inlay-style trochlear component to an onlay-style component can be effective for correcting patellar instability [39].

In the absence of patellar instability, which tends to occur early, progression of tibiofemoral arthritis is the largest late risk after PFA [40]. At a mean of 4- to 5-year follow-up after PFA, 3–4 % required revision to a TKA due to progression of tibiofemoral arthritis [3, 41]; at 15-year follow-up, as many as 25 % may require surgery for progression of arthritis [20]. Knowing this, it is important to find risk factors for progression of tibiofemoral arthritis. To this end, one study found that patients without trochlear dysplasia were significantly more likely to develop tibiofemoral arthritis compared to those with trochlear dysplasia [41]. In the reported series, less than 1 % of patellofemoral arthroplasties have failed because of loosening or wear of the implants, although follow-up in most series has averaged less than 7 years [3, 7, 13–17, 26, 27]. By 15 years, loosening may occur in 2 % [20].

While studies have reported favorable results for patellofemoral arthritis treated with TKA [4, 5], one study retrospectively comparing outcomes in patients undergoing PFA or TKA for patellofemoral arthritis found that patients treated with PFA had higher activity levels [42]. In a meta-analysis comparing PFA to TKA for patellofemoral arthritis, the authors found that there was an eightfold higher likelihood of

Fig. 8 (**a**–**c**) Postoperative AP, lateral, axial radiographs (Gender Solutions PFJ, Zimmer, Warsaw IN)

revision and reoperation after PFA compared to TKA. However, when they evaluated second-generation onlay designs, there was no difference in the incidence of reoperation, revision, mechanical complications or pain, further underscoring the beneficial effect of using onlay-style trochlear designs [43] (Fig. 8).

Summary

PFA can be an effective treatment for patellofemoral arthritis resulting from primary osteoarthritis, dysplasia, or posttraumatic arthritis in patients. The results of patellofemoral arthroplasty can be impacted by the design features of the trochlear component, the presence of uncorrectable patellar instability or malalignment, implant malposition (potentially hastened by particular designs), and tibiofemoral chondromalacia or arthritis. Unlike inlay-style trochlear components, which tend to be internally rotated, onlay-style protheses, positioned perpendicular to the AP axis of the femur, have almost eliminated patellar maltracking after PFA, leaving progressive tibiofemoral arthritis as the primary potential failure mechanism.

As with all knee procedures, MIS techniques can be applied to patellofemoral arthroplasty, but only after the procedure has been performed effectively and accurately through more extensile approaches. The surgical approach should not negatively impact the outcome of patellofemoral arthroplasty because of errors in implantation or fixation, but instead should facilitate outpatient surgery, accelerate the recovery, and optimize early outcomes.

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