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The patella in total knee arthroplasty: to resurface or not is the question

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Abstract The decision to resurface the patella during total knee arthroplasty remains controversial. Even though some surgeons routinely resurface the patella to avoid the increased rates of postoperative anterior knee pain and reoperation for secondary resurfacing, others selectively resurface based on the presence of anterior knee pain, notably damaged articular cartilage, inflammatory arthritis, isolated patellofemoral arthritis, and patellar subluxation and maltracking. The anatomy and biomechanics of the patellofemoral joint, combined with advances in surgical technique and prostheses must be taken into account when making a decision to resurface the patella. Accurate component implantation is imperative for a successful outcome if the patella is resurfaced.

Keywords Patella · Total knee arthroplasty · Resurfaced patella · Unresurfaced patella · Patellofemoral joint

Introduction

Historically, the patella accounted for up to 50 % of total knee arthroplasty (TKA) failures in the 1980s and early 1990s when dissociation or failure of a cementless metal-backed patellar component was the most common device-related complication of TKA [1–4]. However, contemporary studies show that relatively fewer TKAs fail because of patellofemoral complications [5].

Early total knee designs did not take into account the patellofemoral joint. As such, patellofemoral symptoms were common in patients, with some reporting the incidence to be 40 %–58 % [6]. Subsequent designs incorporated an anterior flange but ignored the native patella and its anatomic motion during range of motion (ROM). In 1974, the Insall-Burstein total condylar knee replacement (Zimmer; Warsaw, IN) provided the first patellar resurfacing, a polyethylene dome.

However, numerous complications developed with resurfacing of the patella. These included patellar fracture, extensor mechanism disruption, osteonecrosis, aseptic loosening, instability and dislocation, overstuffing of the patellofemoral joint, polyethylene wear, and patellar clunk syndrome (which has improved with modern designs). In an effort to minimize the above issues, design modifications were made to the patellar components, as well as the femoral articulation. Given the above, some surgeons prefer not to resurface the patella. However, there is a well-documented 10 % risk of secondary resurfacing procedures in patients who do not have their patella resurfaced at the index procedure [7].

International perspective

Currently, there are 3 surgical approaches to the patella during primary total knee arthroplasty: always resurface, never resurface, or selectively resurface based upon patient factors such as quality of the articular cartilage and patellofemoral congruence at the time of surgery. The wide variability is dependent on geographic location and training. In North America, the majority of surgeons (>90 %) routinely resurface the patella. Patellar resurfacing is less common in Asian countries, and

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selectively done in European nations. A recent article by Vielgut et al studied the percentage of patellar resurfacing in TKA in 11 arthroplasty registers from the EFORT website [8•]. Although the Danish knee arthroplasty registry reported a 72 % rate of resurfacing the patella, only 2 % of TKAs completed in Norway and 3 % in Sweden had a patellar button. It is unlikely that the major differences in trends from similar Nordic countries are solely because of cultural differences. Therefore, the assumption is that surgeon choice is attributable to education, training, tradition, experience, and/or clinical evidence. In reality, it is likely to be a combination of these factors.

The vast majority of surgeons routinely resurface the patella in North America for several reasons. Foremost, multiple level 1 randomized trials and well-done meta-analyses have shown a significantly lower rate of secondary resurfacing and reoperation [7, 9–12, 13•, 14•]. Second, although most level 1 randomized trials and subsequent meta-analyses have not shown a statistically significant difference in anterior knee pain, almost all have shown less anterior knee pain in the resurfaced group[7, 9–12, 13•, 14•]. Third, it is difficult to predict the quality or thickness of the patella's articular cartilage at the time of knee arthroplasty, and how long it would last. Finally, there are a large percentage of patients who present primarily with patellofemoral arthritis or with inflammatory arthritis, mandating patellar resurfacing.

In Europe, the attitude toward the patella is variable not only between countries, but also within countries. Those who "always" resurface in Europe do so for the same reasons advocated by North American surgeons. Those who "never" resurface the patella in Europe are in strict opposition and argue that the rate of complications related to patellar resurfacing is unacceptable. They also contend that no study in the literature has definitively shown a clear difference between the 2 attitudes on patellar pain and complications. However, since no meta-analysis or level 1 study has strongly favored one attitude over the other, both groups of European surgeons are able to find argument in support of their belief. The last group of surgeons in Europe selectively resurface the patella. The philosophy of these surgeons is to decide intraoperatively based upon the quality of the patellofemoral cartilage. To our knowledge, there is minimal published data correlating the intraoperative status of the patellofemoral cartilage and postoperative function.

In Asia, surgeons' attitude toward patella resurfacing varies between never resurfacing and selective resurfacing depending on where the surgeons were educated and trained [6]. Patellar resurfacing is very technique dependent and without proper training and skills, it can result in many unwanted complications. When a surgeon is trained to always resurface the patella, then that is what he/she will continue to do in his/her daily practice. The majority of Asian surgeons do not resurface because of patients' smaller statures and thin patellar bone. Another factor against always resurfacing in Asia is the additional cost involved for the primary arthroplasty procedure. Patella resurfacing is only performed when patients have rheumatoid arthritis or severely damaged cartilage. The lack of established national registries and well-designed randomized trials in Asian countries make it difficult to draw conclusions on the actual data of resurfacing vs nonresurfacing. With the lack of concrete evidence of advantages surrounding resurfacing, Asian surgeons are hesitant to always resurface the patella.

It is also important to note that better instrumentation and computer navigation can enhance the position of the femoral and tibial components, and potentially influence the patellofemoral biomechanics in TKA. By contrast, patellar resurfacing remains crude and utilizes poor anatomic landmarks. Computer navigation of the patellar is still unattainable in today's technology. A precise relationship between anterior knee pain after TKA and patellofemoral articulation has yet to be defined.

Until now, the search for the "perfect" design of native patellar friendly components continues, which means that the science of patellar resurfacing has not been perfected yet. For proponents of selective resurfacing, some of the patient factors taken into consideration intraoperatively include native patellar tracking, size and thickness of patella bone, quality of articular cartilage, and presence of inflammatory synovial tissues.

Influence of tibiofemoral joint

For successful patellofemoral tracking, the femoral and tibial components must have the appropriate sizing, position, alignment, and rotation. Foremost, the components must be appropriately sized in both the anteroposterior (AP) and mediolateral (ML) planes. Oversized components can lead to patellar maltracking, overstuffing of the joint, the need for unnecessary lateral releases, and continued pain. In addition, the femoral and tibial components must be placed in the appropriate position to minimize issues with the patellofemoral joint. Components that are inappropriately medial may contribute to patellar maltracking and subsequent failures [15–19]. Similarly, components that are malaligned in the coronal or sagittal plane will contribute to failures of the patellofemoral joint. An overall limb malalignment of >10° of valgus or a femoral component positioned in >7° of valgus increases the Q angle and, thus, maltracking [20, 21]. Finally, and arguably most important, is the rotation of the femoral and tibial components [15, 16, 20, 22, 23].

The relationship between component internal rotation and patellar maltracking was well demonstrated by Berger et al [24]. He was the first to utilize axial imaging in the form of computerized tomography (CT) to evaluate the rotational

alignment of TKA components. In this study, he compared 30 patients with isolated patellofemoral complications after TKA to 20 patients with well-functioning TKAs. He noted a direct correlation between the degree of components' internal rotation and patellar maltracking. Mild combined internal rotation (1°–4°) caused lateral patellar tracking and patellar tilting, whereas moderate internal rotation (5°–8°) caused subluxation, and severe internal rotation (7°–17°) caused patellar dislocation or component failure. The rotation of the tibia is also essential [15, 16, 20, 25]. If the tibial component is internally rotated relative to the cut surface of the tibial plateau, the tibia will be externally rotated relative to the femur. As such, the tibial tubercle will be lateralized and the Q angle increased, predisposing to lateral patella subluxation [16, 26]. This occurs when the surgeon is trying to place a symmetric tibial component that is larger than ideal. Several studies have demonstrated higher revision rates and less favorable clinical results in patients with rotational malalignment of the tibial component [27, 28].

Biomechanics

Multiple biomechanical studies of the patellofemoral joint in TKAs have focused on the kinematics and contact stresses. In the natural patella, there can be up to 20° of tilt as well as flexion-extension in the sagittal plane. Since patellar tracking requires biplane rotation, the acceptable geometry of a patellar component is limited to domed patellar designs in contemporary TKAs. In addition, it is now established that a more anatomic trochlear design can reduce patellofemoral complications [29]. These design changes include lateral orientation of the trochlear groove, a prolonged and deepened intercondylar notch, and high lateral flange [17, 30–33]. The high lateral flange and deep constrained groove theoretically provide centralizing forces to contain the patella.

Biomechanical and clinical studies have tried to detect which characteristics of trochlear designs are the most useful. Petersilge et al did not find a significant reduction in shear forces and/or patellar tracking with an asymmetrical design [34]. In addition, the study demonstrated no difference in mediolateral shear forces with a built-up lateral condylar flange compared with a symmetrical condylar flange. However, increased sulcus depth resulted in better patellofemoral tracking.

Virtually all studies of contact areas and stresses have noted a significant decrease in contact area and consequential increase in contact stress when a TKA is performed [29, 35–37]. The stresses in all of these studies exceed the yield point of polyethylene, and would, thus, predict a much higher rate of polyethylene wear and component failure than has been observed. A contributing factor is the pseudo-meniscus (or so-called patellar meniscus) of fibrous tissue that forms around the unloaded portion of the patellar component [1]. This tissue may transfer load to the peripheral overlying soft tissue and change the contact area and stresses exerted on the component. Optimizing patellar tracking is essential to lowering contact pressure on the patellofemoral joint and reducing the rate of loosening [16].

Considerations for resurfacing the patella

There are many surgeons particularly in North America, who routinely resurface the patella. Some surgeons have advocated resurfacing the patella based upon patellar bone stock, patellar shape, articular cartilage characteristics, and host factors [38]. However, this depends on the unpredictable ability of the surgeon to assess articular cartilage as a surrogate for a successful outcome [39]. For those who selectively resurface, the relative indications for surfacing the patella include the presence of anterior knee pain, notably damaged articular cartilage, old age, inflammatory arthritis, isolated patellofemoral arthritis, patellar subluxation and maltracking, implant design, and obesity. Some authors specifically will not resurface the patella if there is viable cartilage with no exposed bone, adequate patellofemoral congruence, a young patient age, a normally shaped patella of appropriate thickness, and no history of crystalline or inflammatory synovitis [38, 40, 41]. One of the strongest indications for not resurfacing the patella is a very thin and severely eroded patella where thickness of the patella even after conservative resection would be less than 10–12 mm.

In addition, there are 4 groups of patients that deserve additional discussion: those with inflammatory arthritis, those who are obese, those who find stair climbing imperative, and female patients. Traditionally, rheumatoid arthritis has been considered an absolute indication for resurfacing the patella [42]. Robertsson et al reported on 1813 knees with rheumatoid arthritis that were not resurfaced from the Swedish Knee Arthroplasty Registry [43]. They found that 15 % of unresurfaced patellae were unsatisfactory compared with 12 % in a control group of 1208 resurfaced knees. Kawakubo et al studied the thickness of the patella in patients with rheumatoid arthritis and found that although thickness decreased, length and width increased as the patella flattened [44]. In majority of rheumatoid patients, if the patellar thickness had decreased to ≤80 % of the original thickness, patients complained of peripatellar pain.

In addition, obese patients have a higher rate of complications after TKA compared with nonobese patients. Picetti et al found that in patients with an unresurfaced patella, obese patients had more postoperative pain [40]. Healy et al also found a higher rate of patellofemoral complications in obese patients whether or not they had resurfacing of the patella [3]. In the largest randomized controlled trial, Wood et al found that weight, not body mass index (BMI) was associated with

postoperative anterior knee pain in patients with an unresurfaced patella [45].

Multiple studies have also shown that patients with an unresurfaced patella have inferior stair climbing ability. Soudry et al found that 8 of 24 patients with an unresurfaced patella were unable to lead with the involved limb in stair climbing [41]. However, other studies have shown no difference during stair climbing [46].

Finally, gender is an important variable to consider when deciding whether or not to perform patellar resurfacing. Robertsson et al found that female patients were more satisfied with the result of patellar resurfacing than male patients in the Swedish Knee Arthroplasty Registry [43].

Operative technique for resurfacing the patella

The critical surgical factors in patellar resurfacing are maintaining the preoperative patellar thickness, performing a symmetric bone resection, and balancing the extensor mechanism [1, 47]. The patella can be resurfaced anytime during the procedure.

Foremost, the patellar arthritis and erosion must be evaluated. Next the synovial tissue surrounding the patella should be removed circumferentially down to the level of the quadriceps tendon proximally and patellar tendon distally. Removal of this proximal tissue is essential to minimize soft tissue crepitus and patellar clunk in posterior-stabilized designs. In addition, use of electrocautery here can help desensitize the nerve endings surrounding the patella [48]. After this, the thickness of the patellar should be measured with a caliper. The goal is to reproduce the thickness of the patella with the target being equal or 1 mm less than the native patella. Given that most patellar components are 8–10 mm in thickness, an equal amount of bone should be resected. Of note, the patella should not be resected to less than 12–15 mm to minimize the risk of fracture [49]. If under-resected, the patellofemoral joint will be overstuffed and the lateral retinaculum will be tightened resulting in maltracking.

The patellar cut can be completed freehand or with the use of any number of patellar guides. Regardless, the goal is to resect from the medial facet to the lateral facet keeping the saw blade parallel to the anterior surface of the patella. The goal is for the saw blade to exit the junction of the patella and quadriceps tendon proximally, patella and patellar tendon distally, and articular cartilage and subchondral bone laterally. If the patient has a history of subluxation or tilt, the lateral facet may be additional sclerotic and patience should be emphasized.

After the cut is completed, a caliper is once again utilized to measure the thickness in each of the 4 quadrants to ensure they are equal superiorly, inferiorly, medially, and laterally (Fig. 1). Once an equalized surface is created, the patellar-sizing template is placed on the freshly cut surface. The goal is to place the trial as medial as possible without overhanging [15, 31, 50]. In addition, superior placement of the patellar component minimizes patellar clunk and catching in the inter-condylar region [50]. The lugholes are then drilled and the patellar trial is put in place. Next, uncovered bone of the lateral facet is resected with a saw or rongeur to decompress the lateral gutter. An appropriately sized trial component is placed and the thickness is once again measured using the caliper. The patellar tracking is then assessed.

Complications of resurfaced patella

Despite adhering to all of these principles, one experienced surgeon reported an 18 % incidence of asymmetric patellar resection depth and a 10 % incidence of patellar tilt 2.5 years after 50 total knee replacements performed with patellar resurfacing [47]. Other studies have revealed a 7 %–14 % rate of patellar tilt, asymmetry, and subluxation after TKA with resurfaced patellae [22, 51]. Bindelglass et al found that only 55 % of their resurfaced patellae tracked centrally [52]. However, asymmetry and patellar tilt did not correlate with symptoms in any of these studies. In contrast, Pagnano and Trousdale reported asymmetric resurfacing in 21 of 300 knees (7 %) [53]. However, patellofemoral complications were subsequently noted in 11 of those 21 knees (52 %).

The main complications after patellar resurfacing include patellar instability and dislocation, polyethylene wear and aseptic loosening, patellar clunk syndrome, and patellar fracture and osteonecrosis. In an unpublished review of the entire Mayo Clinic experience by Abdel and Berry, 4 (0.02 %) intraoperative patella fractures of 24,000 primary TKAs were identified [54]. All the fractures (4 [0.02 %] of 23,732) occurred during placement of cemented components. During revisions, the intraoperative fracture rate was 20-fold higher: 7 (0.4 %) of 1951. All (7 [0.4 %] of 1927) occurred during placement of a cemented patella. In regard to postoperative periprosthetic patella fractures, the most recent Mayo Clinic data revealed 337 (1.4 %) fractures of 24,000 primary TKAs. Of these, 9 (3.4 %) of 268 occurred with noncemented patellae and 228 (1.0 %) occurred with 23,732 cemented patellae. After revision procedures, the postoperative periprosthetic patella fracture rate was 53 (2.7 %) of 1951. All fractures occurred after placement of a cemented patellar component.

Complications of unresurfaced patella

There are 2 main complications of not resurfacing the patella: anterior knee pain and the need for secondary resurfacing. The reported rate of secondary resurfacing based upon multiple studies is 10 %–12 % [55, 56]. Barrack et al reported on 7 cases of secondary resurfacing for anterior knee pain, which was 12 % of the original series [57]. All 7 patients showed an

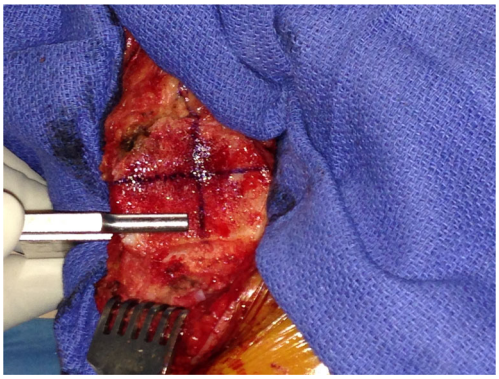

Fig. 1 Intraoperative photograph depicting the lead author's preferred technique for resecting the eroded patellar bone by going from the medial facet to the lateral facet, keeping the saw blade parallel to the anterior surface of the patella. The goal is for the saw blade to exit the junction of the patella and quadriceps tendon proximally, patella and patellar tendon distally, and articular cartilage and subchondral bone laterally. The patella is then divided into quadrants and each quadrant is measured with a caliper to ensure equal thickness, with a target of 14 mm in most cases

initial reduction in anterior knee pain after resurfacing, but 4 deteriorated again approximately 3 years after the revision. Most recently, Parvizi et al also published a comprehensive meta-analysis that included 14 prospective, randomized studies comparing unresurfaced and resurfaced patellae in total knee arthroplasty [7]. There was a lower relative risk of anterior knee pain in the resurfaced group compared with the unresurfaced group (P=0.01). However, there was no statistically significant difference in patient satisfaction or revision surgery between the groups when a random-effects model was incorporated. Parvizi et al described their results of secondary resurfacing in 38 patients (7.5 % rate) [58•]. They found that both components of the KSS significantly improved after the secondary procedure and 31 patients were satisfied. However, 7 patients remained unsatisfied. In another study of 17 patients with symptomatic anterior knee pain after a TKA with nonresurfaced patella, Garcia et al concluded that secondary patellar resurfacing was a reasonable surgical option with low morbidity and complication rates [59].

Clinical outcomes

There have been multiple prospective, randomized trials involving resurfaced and unresurfaced patellae in total knee arthroplasty [39, 45, 46, 48, 57, 60]. One of the most intriguing groups is those patients who underwent bilateral procedures [48, 56, 60]. Enis et al looked at 25 patients with advanced patellofemoral osteoarthritis who underwent bilateral TKAs and found superior pain relief and strength in the resurfaced group [56]. However, Keblish et al found no difference in patient outcomes in those undergoing bilateral mobile-bearing total knee arthroplasties with and without resurfacing [48]. However, this study had a large proportion of patients (44 %) lost to follow-up at 5 years. Burnett et al studied 32 patients who underwent bilateral TKA with and without resurfacing at a minimum follow-up of 10 years [60]. He found no difference in range of motion, patient satisfaction, revision rates, and anterior knee pain.

Multiple meta-analysis outcome studies have previously investigated the merit of resurfacing the patella. Nizard et al performed a meta-analysis of patellar resurfacing in 1490 knee arthroplasties from 12 different prospective, randomized trials [9]. They found a 0.43 increased risk for reoperation with unresurfaced patellae (6.5 % vs 2.3 %, respectively). In addition, there was a 0.39 increased risk of anterior knee pain in the unresurfaced patellae group (22.3 % vs 7.6 %, respectively). Finally, Pakos et al completed a meta-analysis of 1223 knees in 10 prospective, randomized studies from 1995 to 2003 [10]. They found that the risk of reoperation was reduced by 4.6 % in the patellar resurfacing arm. In addition, patellar resurfacing reduced the absolute risk of postoperative anterior knee pain by 13.8 %.

Most recently, Pilling et al completed a meta-analysis of 16 randomized controlled trials and found that patellar resurfacing lead to significantly less reoperation [14•]. However, there was no statistically significant difference in anterior knee pain although the rate was 11 % less in those who had a resurfacing. Another meta-analysis completed by Pavlou et al investigated 18 level 1 randomized controlled trials [13•]. Once again, they found a higher rate of reoperations in the nonresurfacing group, but were unable to compare the incidence of anterior knee pain given the heterogeneity of the data. In 2011, Li et al completed a systematic review of 14 randomized clinical trials relevant to patellar resurfacing [12]. They found that the relative risk of reoperation was significantly lower for the patellar resurfacing group. In addition, the incidence of postoperative anterior knee pain was about 50 % lower in the resurfaced group (12.9 % vs 24.1 %, respectively). Finally, He et al completed a meta-analysis of 16 randomized controlled trials and found that although reoperation was higher in the nonresurfaced group, there was no difference in anterior knee pain or functional scores between the two groups [11].

The big controversy of resurfacing and nonresurfacing the patella revolves around the lack of understanding of why some patients experience anterior knee pain postoperatively and others do not, regardless of their preoperative conditions and patella resurfacing. No conclusive evidence exist to support that resurfacing the patellae will definitely alleviate the pain postoperatively. In a randomized, controlled trial, Barrack et al found that 28 % of patients with resurfaced patellae suffered anterior knee pain postoperatively (AKP) despite not experiencing any anterior knee pain preoperatively [57]. Similarly, 9 % of patients with preoperative anterior knee pain continued to suffer anterior knee pain after patellae resurfacing. In the nonresurfaced group, 23 % continued to suffer pain whereas 14 % developed new pain.

When a patient with a nonresurfaced patella presents with anterior knee pain, there are several remedies available, but the most frequent solution chosen will be secondary resurfacing. In contrary, if anterior knee pain is present in patients with a previously resurfaced patella, then treatment options are more limited. Isolated patella component revision is rarely recommended because of the uncertain and often unfavorable clinical outcomes and frequent complications.

The importance of design issues has been highlighted by Wood et al [45] who conducted a randomized controlled study where the variable was only the type of implant used. Wood et al used a relatively "unfriendly" patellar design featuring flat-shaped condyles with a shallow and angular trochlea groove whereas Smith et al used a relatively "friendly" patellar design featuring a deepened trochlea groove with curved transition toward the femoral condyles. When the results of nonresurfaced patients in both studies were compared, it showed a reduction of reoperation rate because of patellofemoral complications from 12 % to 1.2 %. The rate of postoperative anterior knee pain decreased from 31 % to 21 % and the Knee Society Score (KSS) increased by 11 points. In the 10-year follow-up data of 600 unresurfaced TKAs using a "patella-friendly" design, O'Brien et al [61] found significant anterior knee pain in only 1.5 % of cases requiring secondary resurfacing and concluded that when using a patella friendly design, leaving the patellae unresurfaced does not adversely affect the outcome. In a more recent study, Hwang et al [62] compared the 7-year results of 2 groups of patients receiving patella-friendly designs. The authors were unable to detect any significant differences in anterior knee pain or revision rates between unresurfaced and resurfaced knees. The same inability to associate between implant design and clinical outcomes was shown by Pavlou et al [13•] in their meta-analysis of 7075 cases. However, the rather indiscriminate inclusion criteria when defining "patella-friendly" designs might categorize most implants as "friendly". To our knowledge, the available clinical studies should be considered as being manufacturer- specific and are reliable only for that specific implant system.

Conclusions

Although in North America most surgeons favor resurfacing, different attitudes are still observed in Europe. In Asia, most surgeons do not resurface the patella because of the patients' smaller statures and thinner patellar bone. Another factor against always resurfacing in Asia is the additional cost involved for the primary arthroplasty procedure. Patella resurfacing is typically performed in Asia when patients have rheumatoid arthritis or severely damaged cartilage. The lack of established national registries and well-designed randomized trials make it difficult to draw conclusions on the actual data of resurfacing vs nonresurfacing. The paradigm of selective resurfacing attempts to pinpoint patients who might benefit from patellar resurfacing, while avoiding the added risk of complication because of unnecessary resurfacing. However, the selective criteria remain elusive. Therefore, it is imperative that suitable indicators are defined to tell us who will benefit from resurfacing in order to improve the reliability of surgeons' selection process. Until we can come to an agreed consensus on the best practice of patella resurfacing, surgeons all over the world will continue to practice based on their knowledge, training and experience.

Thus, the answer to our title remains controversial. The consensus in the worldwide literature is that the patella should be resurfaced when inflammatory arthritis is present, the patella is severely deformed, or when patellofemoral joint degeneration is the primary indication for the procedure. Accurate component implantation is imperative for a successful outcome if the patella is resurfaced, particularly appropriate external rotation and sizing of the femoral and tibial components, lateral placement of the femoral and tibial components, medial and superior placement of the patella, and use of a contemporary TKA design.

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Compliance with Ethics Guidelines

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