When performing a total knee arthroplasty (TKA), there is no clear consensus regarding whether to resurface the patella. Worldwide, between 2% and 90% of orthopedic surgeons choose to routinely resurface the patella.1-3 The Australian National Joint Replacement Registry reported that 49.5% of TKAs in 2010 had the patella resurfaced, whereas a study using the joint registry in Norway reported that only 2.6% of all TKAs were done with a patellar resurfacing.4,5 Advocates for patellar resurfacing claim that it may prevent the need for reoperation, address patellofemoral arthritis, improve the functional outcomes, and decrease the chance of developing anterior knee pain that is commonly associated with patellar non-resurfacing.1,6-8 The Insall-Burstein design, created in 1974 (Zimmer, Warsaw, Indiana), was the first construct that allowed surgeons to proceed with resurfacing using a polyethylene dome1 and was introduced to address the high incidence of patello-femoral complications.9-11 However, with the introduction of designs that reconstruct the patello-femoral articulating surface, there was an inadvertent increase in a new generation of postoperative complications, such as patellar fracture, decreased range of motion (ROM), polyethylene wear, component loosening, polyethylene fracture, and patellar clunk syndrome.1,4 Yet, multiple factors, such as achieving an “ideal patellar thickness,” may be associated with the reduction of these complications.3,12,13 Many studies have emphasized that when performing the patellar cuts, the new resurfaced patella must closely mimic the native patellofemoral articulating surface.14,15 In addition, after cutting the patella, a thickness of approximately 15 mm should be achieved, so that when adding the polyethylene, a combined thickness of approximately 25 mm will be obtained to improve the outcomes and to minimize the complications.16-20

Despite numerous studies evaluating patellar resurfacing, there continue to be conflicting thoughts regarding the role of the patellar thickness in optimizing post-TKA outcomes and reducing complications.12,13,15 Therefore, the aim of this review was to evaluate
the role of patellar thickness in (1) range of motion, (2) patient-reported outcomes, (3) periprosthetic patellar fractures, and (4) reoperations in patients undergoing TKA. Secondarily, the authors also attempted to evaluate these outcome measures in the setting of inflammatory knee arthropathies.

**Materials and Methods**

The electronic databases PubMed, EMBASE, and Ovid were searched for all potentially relevant reports from January 1990 to July 2014. The following search strings were used: patella*[title] AND thick*[title] OR width*[title]. A total of 102 articles were found. After reviewing the abstracts of these articles, 20 reports were determined to be relevant and used in this study. Then, the references of these reports were cross-referenced for additional sources and yielded an additional 19 reports relevant to this review. Preference was given to peer-reviewed randomized control trials and meta-analyses conducted in the past 10 years. The following articles were excluded: (1) those not in English, and (2) isolated case reports.

**Range of Motion**

The role of post-resection thickness in ROM has been studied extensively, from both a biomechanical and a clinical perspective. Although this topic is still undergoing extensive research, there are multiple reports describing that there is no association between ROM and patellar thickness. For example, Hsu et al.\(^1\) evaluated the effect of patellar thickness on multiple kinematic measurements of ROM using a biomechanical study of cadaveric legs (7 knees). A standard TKA was performed and each subject had the same amount of patellar bone resected (approximately 10 mm). The kinematics were measured at 3 thickness levels—one with a 2-mm shim, once without the shim, and then with an additional 2 mm resected from the native patella. When measuring the ROM of the knee at each of the 3 patellar thickness levels, the authors found that ROM was not significantly different between them (P>0.05). The authors concluded that from the biomechanical point of view, ROM was not noticeably affected by changes in patellar thickness.

Similarly, Koh et al.\(^9\) assessed the role of patellar thickness in complications and functional outcomes, including ROM. The authors evaluated the differences between 2 cohorts who underwent TKA, 1 with a patellar thickness of 12 mm or less (group 1) and 1 with a thickness of greater than 12 mm (group 2) (56 vs 56 knees, respectively). Before surgery, all of the patients were matched for age, gender, race, preoperative diagnosis, preoperative knee scores, and frequency of lateral releases performed during TKA. The 2 cohorts had similar preoperative patellar thicknesses (P=0.69). After a median follow-up of 33 months for group 1 (range, 20-53 months) and 35 months for group 2 (range, 21-57 months), the authors concluded that there was no significant difference in ROM between the 2 cohorts (P=0.34). Groups 1 and 2 had a median ROM of 110° (range, 70°-130° and 75°-130°, respectively).

Additionally, Ritter et al.\(^2\) evaluated the effect of patellar thickness on ROM in a retrospective case-control study (1146 knees). The subjects were stratified into 5 cohorts based on the difference between the postoperative prosthesis-patellar composite thickness and the preoperative patellar thickness. The cohorts consisted of patients with a patellar thickness of at least 6 mm less than the preoperative thickness, 3 to 5 mm less than the preoperative thickness, 2 mm less to 2 mm greater than the preoperative thickness, 3 to 5 mm greater than the preoperative thickness, or at least 6 mm greater than the preoperative thickness. After a mean follow-up of approximately 3 years (range, 1-7 years), no significant difference was found among all cohorts (P=0.92).

Conversely, some studies have supported the theory that an increased patellar thickness will lead to a decrease in knee ROM. Although this decrease may be statistically significant, it appears to be minimal and clinically irrelevant. A study by Abolghasemian et al.\(^3\) assessed the effect of patellar thickness on flexion at the knee joint. Using a biochemical cadaveric model, they found that increasing thickness caused a significant loss in flexion (P=0.002) (95% confidence interval, 1.78° to 5.89°), but the authors emphasized that this relationship was non-linear. For example, a prosthetic thickness increase from 9 to 12 mm caused a decrease in flexion by approximately 1° per millimeter. However, changing the thickness from 21 to 24 mm caused a reduction in flexion of 3° per millimeter. Similarly, Bengs and Scott\(^23\) evaluated the effect of patellar thickness on the intraoperative knee flexion of patients who underwent TKA (31 knees). The surgeons found that, on average, intraoperative passive knee flexion decreased by 3° for every 2-mm increase in the thickness of the patella (P<0.001).

In summary, there are multiple studies that show no or minimal association between the post-resection thickness and ROM. There are biomechanical and intraoperative studies that have shown changes in ROM based on thickness, but these are small changes in ROM, and postoperative clinical studies have found no association between these 2 variables.

**Patient-Reported Outcome Measures**

Although few studies have investigated the relationship of patient-reported outcome metrics with patellar thickness, current reports have found no association between the post-resection thickness and patient-reported outcomes. In the previously mentioned study by Koh et al.,\(^9\) the functional outcomes were also evaluated using the Knee Society Scoring System. After a median follow-up of 33 months for...
group 1 (range, 20-53 months) and 35 months for group 2 (range, 21-57 months), there was a slight improvement in the functional score in patients who had a thinner patella-prosthesis complex (median, 90 vs 80 points, respectively); however, this difference was not significant ($P = .61$).

Similarly, Ikezawa and Gustilo$^{24}$ evaluated the effect of patellar thickness on outcomes in the revision setting using the Knee Society Scoring System (22 knees). The subjects were divided into a cohort with a patellar thickness of less than 5 mm (11 knees) and a cohort with a thickness of 5 mm or greater (11 knees). After a mean follow-up of 46 months (range, 24-79 months), there was no significant difference in postoperative Knee Society Scoring System scores between the cohorts ($P < .05$). The authors concluded that it is possible to have favorable clinical outcomes in the revision setting when little native patellar bone is remaining, as long as the native thickness is restored.

One study displayed a more complicated relationship between post-resection patellar thickness and outcome measures. Recently, Lee et al$^{30}$ prospectively assessed the effect of patellar thickness on short-term patient-reported outcome measures using Knee Society Scoring System and Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC) scores in a Chinese population (169 knees). After a mean follow-up of 13 months, the authors found that those patients with a residual patellar thickness of less than 12 mm had a significantly lower WOMAC score than those with a thickness of greater than 12 mm ($P = .035$). However, there was no significant difference in the Knee Society Scoring System scores at 6- or 12-month follow-up appointments ($P < .05$). Although these results contradict those of all of the previous studies, this may be due to a smaller population and would be difficult to extrapolate to American populations for 2 reasons. First, the authors indicate that their study cohorts involved an ethnicity known to have smaller mean patellar thicknesses when compared with populations in the United States.$^{9,26}$ Second, the authors report that another limitation is the approximately 1-year follow-up.

In summary, multiple studies have not definitively established an association between post-resection thickness and patient-reported outcome metrics.

**PERIPROSTHETIC PATELLAR FRACTURES**

Previous reports have proposed that if the newly resurfaced patella is too thin, there may be an increased risk of fracture due to an increase in the stresses on the remaining native bone.$^{20,27,28}$ Using a cadaver biomechanical model, Oishi et al$^{27}$ assessed the role of patellar thickness in compression and shear forces (10 knees) within the patello-femoral joint. After placing a load onto each knee, the authors noted greater forces on the thinner patella ($P < .05$). The authors concluded that thinner patellar prosthetic models may have a higher risk of fracturing.

Similarly, Reuben et al$^{30}$ evaluated the strain on the patello-femoral joint using cadaveric knees (10 knees) and a rotary potentiometer. The authors found that patellar strain was increased when the remaining patella was less than 15 mm, and they concluded that these thinner native patellae may be at an increased risk of fracturing.

Aminiouche et al$^{28}$ confirmed these results using a 3-dimensional model of a patella constructed on a digital program. The authors concluded that stress will increase on the patella, both native and prosthetic, as it becomes more thin. More specifically, for every 8 mm of thickness lost to the patella-prosthesis complex, the stress on the native patella increased by approximately 54%. As such, the authors concluded that thinner patellae have a decreased intrinsic capacity to withstand these forces.

In addition to multiple studies using biomechanical models, clinical studies have also confirmed the association between a decreased patellar thickness and increased fracture risk. A recent clinical study by Seo et al$^{30}$ assessed multiple risk factors that may be associated with these fractures by evaluating a consecutive series of TKAs (7866 knees). Along with calculating a fracture prevalence rate of 1.1% in all of the patients, the authors found that patients with a patellar thickness of less than 12 mm had a greater risk of fracturing their patella (odds ratio, 1.6; 95% confidence interval, 1.4 to 1.9; $P < .043$).

Similarly, a biomechanical study by Lie et al$^{30}$ evaluated the amount of strain experienced at different patellar thickness levels (11, 13, and 16 mm) using a biomechanical model (8 cadaver knees) with the same patellar prosthetic component for each native thickness cohort. Their data showed a significantly higher strain in the 11-mm native patellar thickness cohort at 90° of flexion ($P < .05$), but this was not significant at 30° or at 60° of flexion ($P > .05$). The authors noted that the 11-mm patellar thickness cohort may be at a higher risk for fracturing with an increased load on the quadriceps. They also concluded that higher levels of stress are placed on patellae with a reduced post-resection thickness and a higher degree of knee flexion.

Conversely, some studies have shown that thicker patellae may have an increased risk of fracture. This was described by Lombardi et al,$^{31}$ who evaluated a group of patients who underwent TKA and suffered a prosthetic patellar fracture (17 fractures). The authors noted that increasing the thickness of their patella-prosthesis construct was increasing the tension on the extensor mechanism during flexion and therefore increasing the forces placed on the patellar prosthesis. However,
the prosthesis used when this study was conducted was metal backed, and failure rates of these constructs have been much higher than those of their polyethylene counterparts. As such, it may be difficult to extrapolate the results of this study to the use of more recent constructs.

Additionally, a recent study by Meding et al evaluated the potential risk factors that may be associated with patellar failure (loosening, fracture, or revision). After a mean follow-up of 7 years (range, 2-22 years), the authors found a significant association between increasing patella prosthesis thickness and risk of patellar fracture (P=.033). However, when the authors examined the association between post-resection native patellar thickness and patellar fracture risk, there was no relationship between the previously mentioned variables (P=.6).

In addition, some of the literature asserts that there is no association between an increased patellar thickness and a higher risk of patellar fracture. In the previously mentioned study performed by Ritter et al, the authors also investigated the relationship between patellar thickness and fracture risk. After a mean follow-up of approximately 3 years (range, 1-7 years), there was no significant difference in the risk of patellar fracture between the various thickness cohorts (P=.94). However, there was a significant association between the risk of patellar fracture and undergoing a lateral release. The authors concluded that the patellar thickness had no association with the risk of fracturing the patella.

Currently, the literature has differing views on the role of post-resection thickness in the risk of periprosthetic fracture. There may be multiple confounders affecting the relationship between these 2 variables. However, basic science and clinical studies on the most recent generational constructs support the hypothesis that a decreased post-resection thickness may be associated with an increased periprosthetic fracture risk.

REOPERATIONS

Although there are few studies regarding the risk of requiring a reoperation and the effect of the patellar thickness, there are no studies currently displaying a relationship between these 2 variables. In the previously mentioned study performed by Meding et al, the authors found a significant association between decreasing patellar-prosthesis thickness and risk of patellar fracture (P=.03), but no association between increasing patellar-prosthesis complex thickness and the need for component revision (P=.63). Furthermore, the post-resection thickness of the patella had no association with the incidence of complications such as patellar revision (P=.59), loosening (P=.42), or fracture (P=.6012) that may lead to reoperation.

Similarly, in the previously mentioned study conducted by Lee et al in addition to analyzing patient-reported outcomes, the authors also examined potential complications that could lead to a reoperation. After the mean follow-up of 13 months, there were no instances of loosening among the cohort (0 of 169 arthroplasties), regardless of their patellar thickness. Because of these results, the authors from both of these studies concluded that there is no discernible association between increasing patellar thickness and complications or reoperations.

RHEUMATOID ARTHRITIS

Although the previously mentioned studies extrapolate their results to primary osteoarthritis (OA), they do not adequately address patients with inflammatory arthritis, particularly rheumatoid arthritis (RA). Historically, it was standard practice that patients with RA undergo routine resurfacing to a similar patellar thickness as patients with primary OA. However, this has been challenged, particularly in the setting of severe erosion of the native patella such as in advanced RA. In patients with RA or other inflammatory arthopathies that may cause the patella to become thinner over time, it is recommended that the patella-prosthesis complex measure 26 mm in men and 23 mm in women.

Recently, Jujo et al conducted a retrospective review assessing the risk factors associated with patellar fracture after TKA in female patients with RA. The authors calculated a fracture prevalence of 1.5% (5 fractures among 329 knees) and found a significant association between decreasing patellar thickness and risk of fracture (P=.01). On average, those with patellar fractures had a patellar thickness 2 mm less than those without fractures (10 vs 12 mm, respectively). On the basis of these results, the authors recommended that the thickness of the native patella not be less than 11 mm.

Additionally, Deehan et al evaluated patients with RA (126 knees) who underwent TKA without patellar resurfacing or placement of a patellar prosthesis and compared them with patients with primary OA (120 knees) who had received a patellar prosthesis along with resurfacing. The subjects were assessed using the anterior knee function score (patellar score), WOMAC, Harris Hip Score, and visual analog scale scores. After a mean follow-up of 117 months for the RA cohort (range, 96-167 months) and 121 months for the OA cohort (range, 101-168 months), the outcome scores of the 2 cohorts did not differ significantly (P>.05). Furthermore, the surgeons found similar postoperative ROMs for the RA and OA cohorts (112° vs 110°, respectively). From these results, the authors concluded that it may not be necessary to resurface or replace the patella in TKAs for patients with RA.

The ideal post-resection thickness of the native patella for those with inflammatory arthopathies such as RA remains an area of research. However, because of the marked erosion of the native patella that may be seen...
in patients with RA, special consideration must be given to preserving as much of the native patellar bone stock as possible.

**CONCLUSION**

Whether to resurface the patella remains controversial. If the decision to resurface is made, it is important to investigate the factors that may influence the various outcomes associated with different patellar thicknesses. Previous studies have shown that there is minimal to no relationship between an increased patellar thickness and ROM. Although some biochemical and intraoperative studies have attempted to establish an inverse relationship between ROM and patellar thickness, this has not been shown through prospective clinical studies. Furthermore, the literature shows no association between functional outcomes and patellar thickness.

However, if the patella is too thin, there may be an increased risk of prosthetic fracture. If it is too thick, there is no association with increasing risk of complications. To avoid potential patello-femoral complications, based on cadaver biomechanical studies, it may be most beneficial to make the patella-prosthesis complex as similar to the patient’s native knee as possible. However, if the patient has a diagnosis of RA, it may be necessary to consider resecting less of the native patella.

**References**


