Selective Patellar Resurfacing in Total Knee Arthroplasty: A Prospective, Randomized, Double-Blind Study

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Abstract

350 knees were evaluated in a prospective, randomized, double-blinded study of selective patellar resurfacing in primary total knee arthroplasty. Knees with exposed bone on the patellar articular surface were excluded. 327 knees were evaluated at a mean follow-up of 7.8 years. 114 knees followed for greater than 10 years were analyzed separately. Satisfaction was higher in patients with a resurfaced patella. In patients followed for at least 10 years, no significant difference was found. No difference was found in KSS scores or survivorship. No complications of patellar resurfacing were identified. The vast majority of patients with remaining patellar articular cartilage do very well with total knee arthroplasty regardless of patellar resurfacing. Patient satisfaction may be slightly higher with patellar resurfacing.

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Methods

Enrollment

From July 1996 to April 2001, the patients of two surgeons at one center were enrolled in a prospective, blinded, randomized study of selective patellar resurfacing. All patients undergoing primary total knee arthroplasty for a primary diagnosis of osteoarthritis were recruited to participate in this study. Patients with inflammatory arthritis, avascular necrosis, previous patellar fracture or osteotomy, or who were undergoing revision knee arthroplasty were excluded from participation. Patients who were found at the time of surgery to have any exposed bone on the patellar articular surface were excluded. Institutional Review Board approval was obtained prior to the initiation of the study and informed consent was obtained from each patient.

An independent physical therapist examined the lower extremity and obtained a medical history and Knee Society Scores preoperatively. The same researcher, blinded to the treatment allocation, performed treatment outcome analyses separately. Satisfaction was higher in patients with a resurfaced patella. In patients followed for at least 10 years, no significant difference was found. No difference was found in KSS scores or survivorship. No complications of patellar resurfacing were identified. The vast majority of patients with remaining patellar articular cartilage do very well with total knee arthroplasty regardless of patellar resurfacing. Patient satisfaction may be slightly higher with patellar resurfacing.
postoperative evaluations at 6 weeks, 3 months, 1 year, 2 years and every subsequent 2-year interval.

Knee evaluations used for this study were a pre-operative evaluation and a final follow-up (minimum 2-year) evaluation. All knees with a minimum 10-year follow-up were also analyzed separately to provide a comparison to other reports with 10-year follow-up.

The primary outcomes in this study were patient satisfaction, revision, Knee Society score and Knee Society function score. Secondary outcomes included active and passive range of motion, presence of anterior knee pain and stair climbing ability. Satisfaction was documented at each follow-up visit on an ordinal scale [27].

Radiographs were evaluated preoperatively, one year postoperatively and at the time of final evaluation. The radiographs were evaluated for coronal alignment (whether the patella was located centrally, medially or laterally in the trochlea on the Merchant radiograph) Insall ratio, the presence of articular cartilage space on the un-resurfaced patella, whether the patella was congruent to the trochlea and the angle of patellar tilt.

Surgical Procedure

The surgical procedure was performed under spinal anesthesia. No peripheral nerve blocks were used. We employed a midline incision and a medial parapatellar arthrotomy. The patella was everted and the patellofemoral joint was inspected. If exposed bone was found on the patellar articular surface or grossly evident chondrocalcinosis, the patella was resurfaced and the patient was not included in the study. If no exposed bone was found on the patellar articular surface, an envelope was opened instructing the surgeon whether or not to resurface the patella. If the patient was undergoing a simultaneous bilateral total knee arthroplasty, only a single envelope was opened and both patellae were treated the same.

The implant was the DePuy Sigma fixed bearing cruciate-retaining knee system. The femoral component was externally rotated three degrees from the posterior condylar axis and was placed toward the lateral side of the resected femoral surface.

Patellar osteophytes were excised. When the patella was resurfaced the composite patellar thickness was restored to within 2 mm of the pre-resection thickness. The patellar component was an all-polyethylene dome-shaped implant with three fixation pegs. The patellar surface was prepared with standard cementing technique. A lateral retinacular release was performed when the patella was not centered in the trochlea with the knee flexed 45° and the medial capsular retinaculum unapproximated. The superior lateral geniculate artery was identified and preserved when possible.

Postoperatively, a continuous passive motion machine was used for the duration of the hospitalization. Weight bearing as tolerated was allowed immediately; no immobilization devices were used. Physical therapy was prescribed three times a week for four to six weeks.

Randomization

Prior to initiating the study, the assignment of patellar resurfacing had been made by a random number generator. The assignments were placed in opaque envelopes and the envelopes were taken in consecutive order. The envelopes were opened in the operating room after evaluation of the patellar surface. At that time the patient was assigned to the patellar resurfacing or non-resurfacing group. No discrepancies of randomization occurred. The treatment allocation was concealed from the patient. An independent observer who had no knowledge of the treatment allocation performed clinical evaluations.
Table 1
Baseline Demographics and Treatment Group Characteristics (Pre-Operative, Intra-Operative, and Follow-Up).

<table>
<thead>
<tr>
<th></th>
<th>Not Resurfaced</th>
<th>Resurfaced</th>
<th>P Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (yrs, at time of surgery)</td>
<td>172 71.3 7.4 48–90</td>
<td>178 70.2 8.7 48–89</td>
<td>0.199</td>
</tr>
<tr>
<td>BMI (at time of surgery)</td>
<td>172 29.2 5.0 19.5–44.5</td>
<td>178 28.5 5.4 20.1–43.0</td>
<td>0.584</td>
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<tr>
<td>Pre-op Passive ROM</td>
<td>170 119.3 15.4 74–152</td>
<td>176 116.8 16.6 75–150</td>
<td>0.153</td>
</tr>
<tr>
<td>Pre-op Active ROM</td>
<td>171 109.1 15.6 59–141</td>
<td>175 107.8 17.6 47–145</td>
<td>0.494</td>
</tr>
<tr>
<td>Pre-op KS Score</td>
<td>164 32.8 18.3 0–87</td>
<td>170 33.5 18.3 0–88</td>
<td>0.740</td>
</tr>
<tr>
<td>Pre-op KS Function Score</td>
<td>172 50.2 18.2 0–100</td>
<td>178 51.2 17.4 0–100</td>
<td>0.397</td>
</tr>
<tr>
<td>Pre-op KS Stair Sub-score</td>
<td>172 30.7 7.62 0–72</td>
<td>178 31.38 7.32 0–50</td>
<td>0.196</td>
</tr>
<tr>
<td>Pre-op Insall Ratio</td>
<td>141 1.07 0.19 0.70–1.80</td>
<td>162 1.05 0.16 0.72–1.61</td>
<td>0.290</td>
</tr>
<tr>
<td>Deaths (None related to Study)</td>
<td>172 7.4 2.8 1.9–12.2</td>
<td>164 8.2 2.4 1.9–12.0</td>
<td>0.006</td>
</tr>
</tbody>
</table>

Table 2
Final Follow-Up Measurements on Knees With Minimum 2-Year Follow-Up.

<table>
<thead>
<tr>
<th></th>
<th>N</th>
<th>Mean</th>
<th>S.D.</th>
<th>Range</th>
<th>N</th>
<th>Mean</th>
<th>S.D.</th>
<th>Range</th>
<th>P Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>N Mean S.D.</td>
<td></td>
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<tr>
<td>N Mean S.D.</td>
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<td></td>
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<tr>
<td>Minimum 2-year Follow-up</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Passive ROM</td>
<td>140</td>
<td>126.2</td>
<td>10.1</td>
<td>94–150</td>
<td>139</td>
<td>125.1</td>
<td>12.7</td>
<td>78–152</td>
<td>0.438</td>
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<tr>
<td>Active ROM</td>
<td>139</td>
<td>116.6</td>
<td>10.5</td>
<td>86–142</td>
<td>138</td>
<td>116.2</td>
<td>12.6</td>
<td>72–145</td>
<td>0.774</td>
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<tr>
<td>KS Score</td>
<td>138</td>
<td>84.0</td>
<td>13.2</td>
<td>25–100</td>
<td>135</td>
<td>83.7</td>
<td>12.3</td>
<td>12–100</td>
<td>0.867</td>
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<tr>
<td>KS Function Score</td>
<td>162</td>
<td>60.0</td>
<td>28.8</td>
<td>0–100</td>
<td>164</td>
<td>63.0</td>
<td>27.4</td>
<td>0–100</td>
<td>0.318</td>
</tr>
<tr>
<td>KS Stair Sub-score</td>
<td>162</td>
<td>36.0</td>
<td>13.1</td>
<td>0–50</td>
<td>150</td>
<td>36.6</td>
<td>11.2</td>
<td>0–50</td>
<td>0.631</td>
</tr>
<tr>
<td>Increase in Passive ROM</td>
<td>138</td>
<td>8.1</td>
<td>12.9</td>
<td>−16 to 49</td>
<td>139</td>
<td>7.7</td>
<td>13.6</td>
<td>−27 to 43</td>
<td>0.832</td>
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<tr>
<td>Increase in Active ROM</td>
<td>138</td>
<td>8.9</td>
<td>13.1</td>
<td>−27 to 47</td>
<td>137</td>
<td>7.3</td>
<td>14.9</td>
<td>−30 to 48</td>
<td>0.371</td>
</tr>
<tr>
<td>Increase in KS Score</td>
<td>130</td>
<td>50.1</td>
<td>22.4</td>
<td>−7 to 88</td>
<td>130</td>
<td>51.5</td>
<td>21.4</td>
<td>−6 to 93</td>
<td>0.616</td>
</tr>
<tr>
<td>Increase in KS Function Score</td>
<td>161</td>
<td>9.3</td>
<td>26.6</td>
<td>−65 to 70</td>
<td>164</td>
<td>10.5</td>
<td>24.3</td>
<td>−50 to 60</td>
<td>0.538</td>
</tr>
<tr>
<td>Satisfaction</td>
<td>162</td>
<td>4.73</td>
<td>0.57</td>
<td>2–6</td>
<td>153</td>
<td>4.85</td>
<td>0.47</td>
<td>2–5</td>
<td>0.039</td>
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<tr>
<td>Insall Ratio</td>
<td>144</td>
<td>1.10</td>
<td>0.18</td>
<td>0.70–1.60</td>
<td>150</td>
<td>1.08</td>
<td>0.17</td>
<td>0.68–1.59</td>
<td>0.366</td>
</tr>
</tbody>
</table>

**Statistical Methods**

For the purpose of statistical analysis, knees were assumed to be independent and all analyses of knees were carried out on a per knee basis rather than a per patient basis. Means for interval variables were compared with a two-sample t-test. Dichotomous variables were compared with Fisher’s exact test. A P value less than 0.05 was deemed significant.

Baseline demographic variables, preoperative and intra-operative characteristics, average follow-up times and the proportion of deaths during the 12.5-year study period were compared to confirm treatment group independence.

Postoperatively, study endpoint measurements were compared across treatment groups for knees with minimum 2-year final follow-up, and on the subset of knees with minimum 10-year final follow-up. Patient satisfaction was converted to an interval scale, 1 = ‘Definitely Not’ through 5 = ‘Definitely Yes’.

Anterior knee pain while walking was considered as a response variable in three separate logistic regression models evaluating treatment group with age, gender and BMI as predictor variables. Interaction terms were confirmed to be not significant. Each of the Knee Society and range of motion measurements was considered as the response variable in an analysis of covariance (ANCOVA) model with treatment group as a predictor variable and age, gender and BMI as covariates. The purpose of these ANCOVA models was to investigate the impact of age, gender and BMI on each of the Knee Society and ROM measurements, particularly to see if there was a difference across treatment groups after adjusting for these covariate effects. Covariates that were not significant were reduced from respective models stepwise.

A Kaplan Meier survivorship analysis was carried out to obtain survivorship estimates and to compare survivorship curves across treatment groups.

**Results**

During the enrollment period, total knee arthroplasties were performed on 616 knees in 496 patients. Two hundred sixty-six knees in
226 patients were excluded. Of these seventy-nine patients had inflammatory arthritis, avascular necrosis, previous patellar fracture or osteotomy, or were undergoing revision knee arthroplasty. Seventy patients chose not to participate. Seventy-three patients who consented to participate in the study were excluded at the time of the surgery due to finding exposed bone on the articular surface of the patella. Four patients were excluded based on finding chondrocalcinosis at the time of the surgery. Of the excluded patients, 40 had simultaneous bilateral total knee arthroplasties.

Three hundred fifty knees in two hundred seventy patients were included in the study: 178 resurfaced knees (denoted RS) in 138 patients, and 172 not resurfaced knees (denoted NR) in 134 patients. There were 80 patients who had both knees enrolled into this study.

The flowchart in Fig. 1 shows study enrollment and treatment allocation, indicating knees lost to follow-up throughout the course of the study. In some instances, the patient could not return for a follow-up visit. These patients were interviewed by telephone. Of the primary outcomes of the study, the occurrence of reoperation, Knee Society function score and patient satisfaction scores could be obtained, but range of motion and complete Knee Society scores were not available for these patients.

Table 3 displays means and proportions across treatment groups for baseline demographic variables, preoperative and intra-operative knee characteristics, average follow-up times, and the proportion of deaths during the 12.5-year study duration. Other than average follow-up time for knees with minimum 2-year follow-up and the subset of knees with minimum 10-year follow-up, respectively. These results include means for active ROM, passive ROM, Knee Society score, Knee society function score, and the mean increases in these measurements from preoperative measurements. In all results displayed in these tables, the only significant differences across treatment groups were for average satisfaction and the proportion of knees exhibiting effusion in knees with minimum 2-year follow-up. Average satisfaction was lower for knees with not resurfaced patella in knees with minimum 2-year follow-up (P = 0.039); the difference was not statistically significant for the subset of knees with minimum 10-year follow-up. Neither the means of Knee Society and ROM measurements nor the mean increases from preoperative measurements were significantly different across treatment groups.

Three logistic regression models were carried out with anterior knee pain while walking as the response variable (knees with 2-year minimum follow-up); predictor variables were treatment group and age, treatment group and gender, and treatment group and BMI in the respective models. Treatment group was not a significant predictor in any of these models.

ANOVA models of Knee Society Function Score, Knee Society Score, active ROM and passive ROM as response variables (knees with 2-year minimum follow-up) were carried out with treatment group as a predictor variable and age, gender and BMI as regression covariates. The covariate-adjusted treatment group means were not significantly different in any of these models.

A Kaplan–Meier survivorship analysis was carried out to analyze revisions for any reason. Knees were followed from the time of surgery until the time of revision or the time of censoring, which was the last known follow-up time or the time of death. Nine of 172 (5.8%) not resurfaced knees were revised during the study duration, and five of 178 (2.8%) resurfaced knees. The results demonstrated a 90.4% survival for not resurfaced knees at 10.5 years and a 91.4% survival for resurfaced knees at 10.4 years (the times when 20 subjects in each respective treatment group remained uncensored; all revisions happened prior to these times). The difference in survivorship between treatment groups was not statistically significant (log-rank P value = 0.207) (Fig. 2).

Complications

Manipulation

Six manipulations under anesthesia were performed for limitation of range of motion in the early postoperative period. Three of these had patella resurfacing and three had not resurfaced patella.
Infection sustained a fracture. Fracture unrelated to the patellar resurfacing. One patient with a resurfaced patella underwent an arthroscopy for removal of a fragment of bone cement detected radiographically. One patient with a resurfaced patella had patella baja and impingement of the inferior pole of the patella on the tibial polyethylene. The inferior pole of the patella was debrided and the polyethylene insert was trimmed with resolution of his symptoms. The patella was not resurfaced at the time of the second surgery. The remaining ten revisions were for chronic effusions and synovitis secondary to polyethylene wear at an average of 7.4 years post-operatively (range 3.6–10.4 years). These patients did not have anterior knee pain. In five knees the patella had been resurfaced and in five knees the patella had not been resurfaced at the index operation. All of the resurfaced patellae had stable, intact implants present at the time of revision. Considering our absence of complications with patellar resurfacing, we elected to resurface the previously not resurfaced patellae at the time of revision for polyethylene wear. All ten patients had relief of their chronic effusions and have not required further surgery. Although we found that there were more effusions in the resurfaced knees than the non-resurfaced knees, this finding is of uncertain clinical significance. These effusions may be due to increased wear debris from the cumulative effect of an additional polyethylene articulating surface in resurfaced knees.

Discussion

When our randomized study was initiated in 1996, patellar complications were considered to be the most common cause of failure in total knee arthroplasty [16,22]. There was controversy whether or not to resurface the patella during total knee arthroplasty. Since that time, several well-designed, long-term, randomized studies of patellar resurfacing with mean follow-up of greater than 5 years have been published [13,16,24–26,28]. These authors reached differing conclusions regarding the advisability of routine patellar resurfacing. One feature of these reports is that all knees were enrolled in the randomization regardless of the severity of the articular cartilage loss in the patellofemoral articulation. Many surgeons who selectively resurface the patella do so based on the appearance of patellar articular cartilage at the time of surgery. Our study investigates the outcome of this approach to patellar resurfacing. We randomized only those knees with no exposed bone on the undersurface of the patella at the time of knee arthroplasty to determine whether the outcome of patellar resurfacing outweighed the potential advantages of leaving the patella not resurfaced in those knees with patellar articular cartilage remaining. We chose this criterion for inclusion as it was a simple, reproducible distinction that can be made at the time of surgery for stratifying patellar articular cartilage damage.

Our results show that the vast majority of patients with remaining patellar articular cartilage do very well with total knee arthroplasty [13,16,24–26,28]. These authors reached differing conclusions regarding the advisability of routine patellar resurfacing.

Loosening

No patellar component was found to loosen clinically or radiographically. One knee had asymptomatic loosening of the tibial component detected radiographically. One patient with a resurfaced patella underwent an arthroscopy for removal of a fragment of bone cement unrelated to the patellar resurfacing.

Fracture

One patient with a nonresurfaced patella sustained an undisplaced patellar fracture two years after his knee arthroplasty. This healed uneventfully with immobilization. No patient with a resurfaced patella sustained a fracture.

Infection

There was one superficial infection in the immediate postoperative period treated with incision and drainage and antibiotics. There was one deep infection that occurred 2.5 years postoperatively and was treated successfully with debridement, insert exchange and a six-week course of antibiotics. Both infections were in patients with resurfaced patellae.

Revisions

There were 14 revisions (9 not resurfaced knees and 5 resurfaced knees), all of which occurred more than 2 years post-operatively. Four knees were revised for anterior knee pain. One patient with a not resurfaced patella had anterior knee pain with stairs that started shortly postoperatively. Her patella was resurfaced 3.0 years after her index arthroplasty. Her pain did not improve after secondary patellar resurfacing. A second patient with a not resurfaced patella underwent patellar resurfacing for anterior knee pain 2.9 years after her index arthroplasty. She was found to have exposed bone on the undersurface of the patella. Her anterior knee pain was not improved after resurfacing. A third patient with a not resurfaced patella had anterior knee pain with stairs and arising from chairs. At the time of secondary patella resurfacing, 8.5 years after her index arthroplasty she was found to have exposed bone on the patellar articular surface. Her knee pain resolved after patellar resurfacing. A fourth patient with a non-resurfaced patella had patella baja and impingement of the inferior pole of the patella on the tibial polyethylene. The inferior pole of the patella was debrided and the polyethylene insert was trimmed with resolution of his symptoms. The patella was not resurfaced at the time of the second surgery.

The remaining ten revisions were for chronic effusions and synovitis secondary to polyethylene wear at an average of 7.4 years post-operatively (range 3.6–10.4 years). These patients did not have anterior knee pain. In five knees the patella had been resurfaced and in five knees the patella had not been resurfaced at the index operation. All of the resurfaced patellae had stable, intact implants present at the time of revision. Considering our absence of complications with patellar resurfacing, we elected to resurface the previously not resurfaced patellae at the time of revision for polyethylene wear. All ten patients had relief of their chronic effusions and have not required further surgery. Although we found that there were more effusions in the resurfaced knees than the non-resurfaced knees, this finding is of uncertain clinical significance. These effusions may be due to increased wear debris from the cumulative effect of an additional polyethylene articulating surface in resurfaced knees.
improvement in patient satisfaction at final follow-up (average 7.8 years) in patients with resurfaced patellae. Although this difference was statistically significant, the clinical significance may be minimal.

We separately examined all 114 knees that could be followed for greater than ten years. This is the largest group of patients reported with 10-year follow-up in a randomized study of patellar resurfacing. These knees were not different than the larger group of patients with shorter follow-up except that the improved patient satisfaction in resurfaced patients no longer achieved statistical significance.

As with other reports [13,24,29], our results demonstrated that patients whose patella was not resurfaced at the index total knee arthroplasty tended to have a higher revision rate although this difference did not achieve statistical significance. Additionally, our results confirm that secondary patellar resurfacing for anterior knee pain in the setting of a previously not resurfaced patella does not necessarily result in the resolution of the pain [30–38]. As noted by Burnett [39] there are many causes of anterior knee pain other than the patellofemoral joint. Therefore, in the setting of a not resurfaced patella, the surgeon may recommend patellar resurfacing for persistent anterior knee pain assuming that the pain is coming from the not resurfaced patella, but if the patella has been previously resurfaced, no operation may be suggested. Managing a patient with a not resurfaced patella and persistent anterior knee pain may result in a secondary resurfacing because it is an available option. There is, however, little to offer a patient if the patella is already resurfaced and other clinical and imaging findings are unremarkable [24]. This may account for the greater prevalence of reoperation in patients with not resurfaced patellae and also for the finding that in many patients secondary patellar resurfacing does not lead to resolution of their anterior knee pain.

We found no complications of patellar resurfacing at follow-up as long as twelve years. Other reports have described patellar fracture, synovial impingement, osteonecrosis, instability, loosening and wear as a result of patellar resurfacing [40–43]. However, many of these results were reported prior to understanding the drawbacks of metal-backed patellar implants and the importance of restoring patellar thickness and appropriate patellar tracking.

Several authors have suggested that a randomized study of selective patellar resurfacing may help resolve the controversy of the indications for patellar resurfacing in total knee arthroplasty [44,45]. We know of only one other prospective randomized study that addressed selective patellar resurfacing [46]. These authors stratified patients by Outerbridge classification. Patients were separately randomized to resurfaced or not resurfaced patella. The only outcome measure examined was reoperation for anterior knee pain. They reported that the risk of patellar resurfacing was 21 times greater when the patella was not resurfaced in the Outerbridge 4 knees compared to the Outerbridge 1–3 knees. These authors concluded that the patella need not be resurfaced in Outerbridge 1–3 knees, but should be resurfaced in Outerbridge 4 knees. Since these authors only evaluated the risk of reoperation and did not examine knee pain or function measures, these results have limited utility for the surgeon deciding whether or not to resurface the patella in patients with remaining patellar articular cartilage.

A limitation of any study of patellar resurfacing is that the findings may be specific to the implant design that was studied. The shape and depth of the trochlear groove of the femoral component are important factors in the contact forces of the articular cartilage of the not resurfaced patella [47–50]. This may explain why Waters et al [13] found a much higher prevalence of anterior knee pain in patients randomized to not resurfaced patellae. These authors employed an implant with a shallow trochlear groove that was less accommodating to the native patellar cartilage. The design used in our study has a deeper, more capacious trochlea that may be more accommodating to the native patella.

In conclusion, we aimed to answer the question of whether or not to resurface the patella at the time of total knee arthroplasty in those knees with remaining patellar articular cartilage. Unlike previous studies, we specifically excluded knees with loss of patellar cartilage down to exposed bone. We hypothesized that leaving the native patellar articular cartilage in this selected population would result in a better outcome than previous reports of randomized patellar resurfacing that were not selective as to the condition of the patellar articular cartilage. However, despite employing an implant with a trochlear groove more accommodating to the native patella and excluding knees with exposed bone in the patellar articular surface, resurfaced knees had slightly better patient satisfaction than not resurfaced knees. While we demonstrated that excellent results can be achieved with not resurfacing the patella, the absence of complications we found with resurfacing suggests that the surgeon can confidently resurface the patella without the risks previously associated with patellar resurfacing using older techniques or earlier component design.

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