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KNEE ARTHROPLASTY

# Patella resurfacing is not associated with a difference in the Oxford knee score after total knee arthroplasty but stair descent is enhanced

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## Abstract

**Background** The primary aim was to assess the Oxford knee scores (OKS) on patients who underwent a total knee arthroplasty (TKA) with patellar resurfacing compared to those who did not. Secondary aims were to identify: (1) factors associated with resurfacing, (2) the effect of resurfacing on specific components of the OKS related to patellofemoral function, (3) the influence on patient satisfaction, and (4) whether a subgroup of patients had an improved outcome when resurfacing was undertaken.

**Methods** A retrospective cohort study was undertaken using outcome data from the arthroplasty database held at the study centre. Patient demographics and OKS were collected preoperatively and at 1 and 2 years postoperatively. Patient satisfaction was assessed at 1 and 2 years postoperatively.

**Results** Three thousand one hundred and twenty-two patients met the inclusion criteria of which 46.5% ($n=1453$) underwent resurfacing. There were no differences in the OKS change at 1 or 2 years between those undergoing and not undergoing resurfacing (difference 0.2, $p \geq 0.469$). Patients undergoing resurfacing were more likely to be female (odds ratio (OR) 1.53, 95% CI 1.30–1.79, $p < 0.001$), undergo a posterior stabilised knee (OR 6.87, 95% CI 5.71–8.27, $p < 0.001$) or had a worse response to question 5—standing from a chair, ($p=0.011$) or 12—stair descent, ($p=0.017$) of the OKS preoperatively. There was no difference in postoperative patient satisfaction ($p \geq 0.180$). There was a significantly greater improvement in question 12 of the OKS at 1 year ($p=0.019$) in the resurfaced group. There were no patient-related factors or symptoms that were associated with a clinically significant ($\geq 5$ points) greater postoperative OKS.

**Conclusion** Patella resurfacing was not associated with a clinically important improvement in OKS. No specific indications for patella resurfacing were identified that offered an improved outcome, but when it was undertaken there was a greater improvement in the ability to descend stairs.

**Level of evidence** Retrospective diagnostic study, Level III.

**Keywords** Patella · Resurfacing · Change · Difference · Total knee arthroplasty · Outcome · Oxford Knee Score

## Introduction

There remains no consensus on whether to resurface the patella or not as part of total knee arthroplasty (TKA) [1]. Global practice is varied with rates of patella resurfacing ranging from 2% in Sweden, 60% in Australia and over 80% in the USA [2]. In the UK, data from the National Joint Registry (NJR) of England, Wales and Northern Ireland suggest that approximately a third of all registered TKAs have a resurfaced patella [3]. Data over the last 10 years, however, suggest that the rate of resurfacing has increased in the UK and Australia [2]. The reasons for this trend are not clear. Results from recent meta-analyses are conflicting, with some demonstrating lower

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re-operation rates, less anterior knee pain and better functional scores associated with patella resurfacing [1, 4–7], whereas others have found no clinical difference in functional scores or anterior knee pain [8–11]. Despite these inconsistent data, the National Institute for Clinical Excellence supports resurfacing, which was demonstrated to be potentially more cost-effective due to the lower re-operation rate [12].

A sample of UK arthroplasty surgeons showed that approximately 25% always resurface, 25% never resurface and 50% selectively resurface [13]. Selective resurfacing may acknowledge the controversies in the literature and offers a compromise in trying to identify and offer resurfacing to patients that may benefit from this following their TKA. However, the evidence regarding the validity of selection criteria remains elusive and the decision when to resurface is often based on intuitive reasoning alone [14]. Severity of patellofemoral osteoarthritis on pre-operative radiographs and intra-operative assessment of patella cartilage loss have been unreliable in predicting functional outcomes [15–17]. To the authors' knowledge, there are no previous publications assessing whether patient demographics, comorbidity, preoperative knee specific function, quality of life or specific activities related to patellofemoral joint function are associated with an improved postoperative outcome when patella resurfacing is performed at the time of the TKA. This may help identify patients who could benefit from resurfacing primarily from those who may not and therefore aid decision-making in selective resurfacing.

The primary aim of this study was to assess whether there was a clinically significant difference in mean Oxford knee scores (OKS) after primary TKA for patients who underwent patellar resurfacing compared to those who did not. The secondary aims were to identify: (1) preoperative demographics and patient-reported symptoms associated with patella surfacing, (2) whether specific components of the OKS related to patellofemoral function were influenced by patella resurfacing, (3) whether patient satisfaction is influenced by patella resurfacing and (4) whether there were preoperative factors associated with a greater knee-specific outcome when patella resurfacing was undertaken.

## Materials and methods

A retrospective cohort study was undertaken using data from an in-house arthroplasty database held at the study centre. This was a single-centre, Orthopaedic Hospital. All patients undergoing arthroplasty (hip and knee) were included in the database. Over a 42-month period (01/06/2012–31/12/2015), 5857 patients underwent primary, unilateral knee arthroplasty. Data from 25 surgeons using different implants[1] (TKA) and techniques (cruciate retaining and posterior stabilized) were included. Patients with a history of post-traumatic osteoarthritis or prior high tibial osteotomy were excluded. The theatre database was used to identify whether patients had undergone resurfacing or not. Patients' radiographs were reviewed to assign implant design type (cruciate retaining [CR] or posterior stabilized [PS]). Patients were excluded if this information (resurfacing or not) was missing, or if implant type was not obtainable.

Patient demographics, body mass index (BMI) and American Society of Anaesthesiologists (ASA) grade were recorded preoperatively. The OKS [18] and EuroQoL (EQ) [19] general health questionnaire were recorded preoperatively and at one and two years post-operatively.

The OKS is a validated, joint-specific, patient-reported outcome measure (PROM). It consists of 12 equally weighted questions assessed on a Likert scale with values from 0 to 4. A summative score is then calculated where 48 is the best possible score (least symptomatic) and 0 is the worst possible score (most symptomatic). The minimal clinically important difference (MCID) for the OKS is 5 points, which is thought to represent a clinical difference between two groups of patients [20, 21]. Using the MCID, if there was difference of 5 points or more in the mean OKS between patients that underwent resurfacing and those that did not, a clinically significant difference was defined to exist. Questions 3, 5, 7 and 12 of the OKS were specifically selected for assessment as these were thought to be associated with patellofemoral joint function and therefore of interest in regard to patella resurfacing:

Q3. Have you had any trouble getting in and out of the car or using public transport because of your knee? (With or without a stick)
Q5. After a meal (sat at a table), how painful has it been for you to stand up from a chair because of your knee?
Q7. Could you kneel down and get up again afterwards?
Q12. Could you walk down a flight of stairs?

The EuroQoL (EQ) general health questionnaire evaluates five domains (5D) recorded preoperatively and at 1 and 2 years postoperatively [19]. The EQ5D assesses mobility, self-care, usual activities, pain/discomfort and anxiety/depression [19]. The 3L version of the EuroQoL questionnaire was used, with the responses to the five domains being recorded at three levels of severity. This index is on a scale of -0.594 to 1, where 1 represents perfect health, and a score less than zero represents a health state worse than death [22].

[1] Implants: (PFC Sigma (Depuy), Genesis II (Smith and Nephew), BKR (JointMedica), TC PLUS (Smith and Nephew), LCS (Depuy), Attune (Depuy), Unity (Corin), Vanguard (Zimmer Biomet), NexGen (Zimmer Biomet), GMK Sphere (Medacta), MRK (MatOrtho), SAIPH (MatOrtho), EndoModel (LINK), and NOILES (DEPUY).

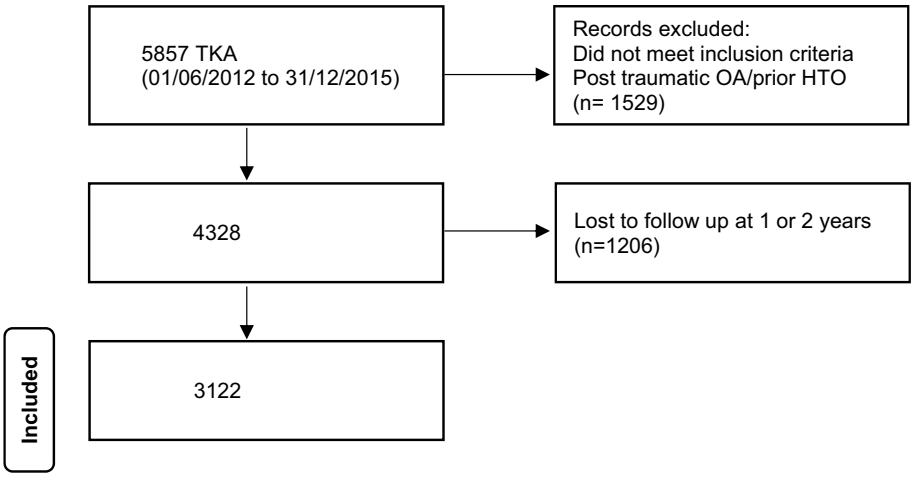


**Fig. 1** Flow chart demonstrating numbers screened for inclusion and numbers lost to follow up

Patient satisfaction was assessed at 1 and 2 years postoperative by asking: "We would like you to indicate on this scale your overall satisfaction with the outcome of your operation". This was assessed using a visual analogue scale from zero (not satisfied) to 100 (very satisfied). Patients scoring 60 or more were classified as satisfied with their TKA.

Statistical analysis was performed using Statistical Package for Social Sciences version 17.0 (SPSS Inc., Chicago, IL, USA). A Student's *t* test, paired and unpaired, was used to compare linear variables between groups. Dichotomous variables were assessed using a Chi-square test or a Fisher's exact test if there was a frequency of five or less in a cell. Pearson's correlation was used to assess the relationship between linear variables. Multivariate linear regression analyses were used to identify independent predictors associated with the 1- and 2-year OKS. Multivariate logistic regression analyses were used to identify independent predictors of patient satisfaction at 1 and 2 years. A *p*-value of $<0.05$ was defined as significant. A post hoc power calculation was performed using the OKS (primary outcome measure) using the MCID of 5 points with a standard deviation (SD) of 10 points, an alpha of 0.05, and using a two-way analysis a power of 100% was achieved using the study cohort ($n=1673$ versus $n=1454$).

There was no additional patient contact, and as such this project was performed as a service evaluation without the need for formal ethical approval. The project was registered with the institution's audit department and was conducted in accordance with the Declaration of Helsinki and the guidelines for good clinical practice [23].

## Results

There were 3122 TKA performed during the study period with complete pre- and postoperative data that met the inclusion criteria (Fig. 1). There were 1193 (38.2%) male patients and 1929 (61.8%) female patients, with a mean age of 70.5 (SD 9.0, range 32–94) years. The mean pre-operative OKS was 20.7 (SD 7.9), and at 1 year postoperatively this increased to a mean of 36.5 (SD 9.3); the 15.7 points improvement was significant (95% confidence interval (CI) 15.4–16.1, $p<0.0001$ paired *t*-test). At 2 years post-operatively the OKS increased further to 36.9 (SD 9.6) and the 16.2 points improvement was significant (95% CI 15.9–16.5, $p<0.0001$ paired *t*-test). There were 1669 (53.5%) patients undergoing TKA without patella resurfacing and 1453 (46.5%) patients that also received patella resurfacing.

### Preoperative factors associated with patella resurfacing

Patients undergoing patella resurfacing were more likely to be female (odds ratio (OR) 1.55, 95% CI 1.34–1.79, $p<0.001$) and had a significantly ($p=0.020$) worse response to questions 7 (kneeling) and 12 (stairs) of the OKS (Table 1, Fig. 2). When adjusting for confounding factors between the groups female sex (OR 1.53, 95% CI 1.30–1.79, $p<0.001$) and questions 5—standing from a chair ($p=0.011$) and 12—stair descent ($p=0.017$) of the OKS were factors independently associated with an increased likelihood of patients undergoing patella resurfacing (Table 2). Patients receiving a PS implant were more likely to undergo resurfacing (Table 2).

### Functional outcome and patient satisfaction

Both groups had a clinically and statistically significant improvement in the OKS at 1 and 2 years following surgery (Table 3). There was a 0.3 point greater improvement at 1 and 2 years in the resurfaced group; however, this was neither clinically nor statistically significant (Table 3). When adjusting for confounding factors between the group's patella resurfacing was not independently associated with a significant improvement in the OKS (0.2, 95% CI − 0.4

**Table 1** Patient demographics and pre-operative functional scores according to group

| Demographic | Descriptive | Patella resurfacing | | Odds ratio/Difference | 95% CI | | *p*-value* |
|---|---|---|---|---|---|---|---|
| | | No ($n=1669$) | Yes ($n=1453$) | | Lower | Upper | |
| Gender (M/F) (*n*, % of group) | Male | 717 (43.0) | 476 (32.8) | Reference | | | |
| | Female | 952 (57.0) | 977 (67.2) | OR 1.55 | 1.34 | 1.79 | **< 0.001** |
| Mean age (years: mean, SD) | | 71.4 (8.5) | 71.6 (8.6) | 0.2 | − 0.4 | 0.8 | 0.515** |
| BMI (kg/m$^2$: mean, SD) | Under | 5 (0.3) | 2 (0.1) | 0.46 | 0.09 | 2.39 | 0.457*** |
| | Normal | 177 (10.6) | 154 (10.7) | Reference | | | |
| | Over | 553 (33.1) | 503 (34.6) | 1.04 | 0.82 | 1.34 | 0.729 |
| | Obese 1 | 549 (32.9) | 481 (33.1) | 1.01 | 0.78 | 1.29 | 0.999 |
| | Obese 2 | 278 (16.7) | 299 (20.6) | 1.24 | 0.94 | 1.62 | 0.124 |
| | Obese 3 | 109 (6.5) | 112 (7.7) | 1.18 | 0.84 | 1.66 | 0.337 |
| | Missing | 0 (0) | 1 (0.1) | N/A | – | – | 0.468*** |
| ASA grade | 1 | 153 (9.2) | 115 (7.9) | Reference | | | |
| | 2 | 1271 (76.2) | 1135 (78.1) | 1.18 | 0.92 | 1.52 | 0.195 |
| | 3 | 243 (14.5) | 201 (13.8) | 1.10 | 0.81 | 1.49 | 0.549 |
| | 4 | 2 (0.1) | 2 (0.1) | 1.33 | 0.18 | 9.57 | 0.999*** |
| TKA design | CR | 823 (49.3) | 186 (12.8) | Reference | | | |
| | PS | 845 (50.6) | 1267 (87.2) | 2.04 | 1.92 | 2.17 | **< 0.001**** |
| Preoperative functional measures (mean, SD) | | | | | | | |
| Oxford Score | Full | 20.8 (8.0) | 20.6 (7.9) | *0.1* | − 0.4 | 0.7 | 0.599** |
| | Q3 | 2.11 (0.86) | 2.11 (0.85) | *0.00* | − 0.06 | 0.06 | 0.974** |
| | Q5 | 1.85 (0.89) | 1.81 (0.86) | *0.04* | -0.02 | 0.10 | 0.217** |
| | Q7 | 0.91 (0.92) | 0.84 (0.92) | *0.08* | 0.01 | 0.14 | **0.020**** |
| | Q12 | 1.93 (0.93) | 1.86 (0.88) | *0.08* | 0.01 | 0.14 | **0.020**** |
| EQ5D | | 0.446 (0.308) | 0.452 (0.306) | *0.006* | − 0.016 | 0.027 | 0.583** |

Statistically significant values are indicated in italics

*N/A* not applicable

*Chi-square test unless otherwise stated

***t*-test

***Fisher's exact test

to 0.8) at 1 or 2 years (Table 4). There was, however, a significantly greater improvement in question 12-stair descent of the OKS at 1 year ($p=0.019$), with an observed trend towards significance ($p=0.094$) at 2 years in the patella-resurfacing group compared to those not undergoing resurfacing (Table 5, Fig. 3). There was no significant difference in patient satisfaction at 1 or 2 years between the two groups (Table 6), which was affirmed on adjusting for confounding factors at 1 year (OR 0.83, 95% 0.63–1.09, $p=0.180$) or at 2 years (0.98, 95% CI 0.74–1.29, $p=0.891$).

### Preoperative factors influencing the knee-specific outcome of patella resurfacing

When assessing the change in the OKS at 1 year for those patients undergoing patella resurfacing and those who did not according to preoperative factors, only patients with an ASA grade of 3 had a statistically greater improvement in their score (Table 7); however, this was not clinically significant. All scores were trending towards being greater for all factors assessed (Table 7). A similar trend was also observed in the change in the OKS at 2 years.

## Discussion

This study has shown that female patients, those receiving a PS implant and those with poor ability to descend stairs or stand from sitting were more likely to undergo patella resurfacing as part of their TKA. When adjusting for these confounding factors, patella resurfacing was not associated with clinically or statistically greater improvement in the OKS at 1 or 2 years following TKA when compared to those patients that did not undergo resurfacing. There was, however, a statistically significant improvement in stair descent score in patients who underwent patella resurfacing after

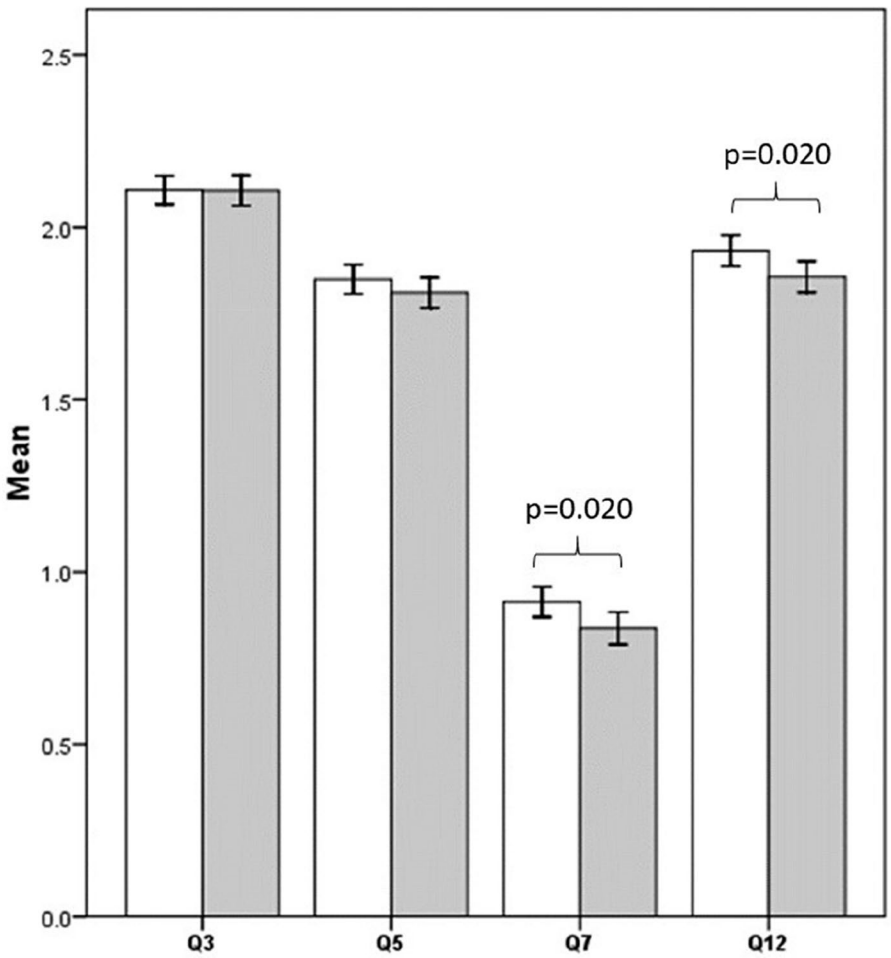


**Fig. 2** Bar chart illustrating the pre-operative mean score for questions 3, 5, 7 and 12 of the Oxford knee score according to whether the patella was resurfaced (grey) or not (white). The error bars represent the 95% confidence intervals

1 year, when compared to those that did not. Despite this difference, there was no association with patient satisfaction and patella resurfacing. Furthermore, there were no preoperative factors identified associated with a clinically greater improvement in the OKS when patella resurfacing was undertaken relative to when it was not performed.

This study did not demonstrate a statistical or clinically significant advantage of patella resurfacing when using the OKS as the joint-specific PROM. This is consistent with data from a meta-analysis by Teel et al. [8] who also found no significant difference in the OKS. Migliorini et al. [5] & Pilling et al. [9] have shown a significant improvement in resurfacing versus not resurfacing when using the Knee Society Score (KSS) as an alternative outcome measure, but neither were clinically significant [24]. These data, however, have not been corroborated in further meta-analyses using the KSS [6, 25, 26]. The KSS is different to the OKS and is predominantly composed of objective measures that are surgeon assessed such as range of movement, whereas the OKS is exclusively composed of subjective questions answered by the patient [27]. Despite these numerous joint-specific knee scores being used to assess the outcome of resurfacing, none were designed or validated to assess the patellofemoral joint (PFJ). Furthermore, the MCID use for the OKS is not specific to the PFJ either. Therefore, the failure of the current study to demonstrate a functional advantage of patella resurfacing, should there be one, using the OKS, although joint-specific is not PFJ-specific, may well have been expected. Knee joint-specific scores such as the OKS and KSS may not be sensitive enough to detect the potential functional advantage of patella resurfacing due to the ceiling effect of the scores [28]. A more sensitive score with a lower postoperative ceiling effect, such as the forgotten joint score [29], may demonstrate the functional advantage of patella resurfacing as part of TKA. This scoring system is based on the concept of the patient's ability to forget the artificial joint in everyday life [29]. The FJS has a lower ceiling effect than the OKS and has shown promising discriminatory power between patients with a good outcome and patients with an excellent outcome [30, 31].

The OKS was originally designed to be used as an inclusive 12-question PROM and was not designed to be broken up into individual subgroups for assessment [18]. The designers, however, have since subgrouped the OKS

into functional and pain subscales [32], which have subsequently been validated for floor and ceiling effects [33]. The four questions assessed in the current study are believed by the authors to be representative of patellofemoral function. To the authors' knowledge, three other studies have assessed individual components of the OKS as a measure of patellofemoral joint function [34–36]. Yassa et al. [34] assessed questions 5, 7, 12 and 10 (the knee giving away) between 66 patients undergoing either patellofemoral arthroplasty or medial unicompartmental arthroplasty as the control. They identified trends that were suggestive that these questions were related to PFJ function. The study, however, was underpowered and they were unable to confirm whether these questions were predictive of PFJ pathology pre-operatively, nor which symptoms would likely improve following patellofemoral arthroplasty. Chua et al. [35] compared the same subgroup of OKS questions (3,5,7, and 12) used in the current study between modern implants with theoretical improved patellofemoral kinematics and traditional implants, but found no difference although the patella was resurfaced in both groups [35]. Baker et al. [36] assessed questions 5, 7 and 12 of the OKS between patella resurfacing and retaining techniques in a large retrospective cohort study using NJR outcome data, and also compared implant brand and design (cruciate retaining or sacrificing). They found no difference in total OKS or individual PFJ sub-scores between resurfacing or not regardless of implant brand or design, the follow-up period was, however, limited to 6 months. It has been shown that there is a significant improvement in OKS from 6 months to 1 year, and therefore, outcome measures at 6 months only may not have identified potential differences between techniques [37, 38]. The current study did, however, show a greater improvement in question 12 of the OKS, relating to stair descent, in those undergoing resurfacing, which is novel. Whether this difference is clinically significant is not clear when considering that there was no difference in patient satisfaction. This was, however, for overall satisfaction and not specifically in relation to PFJ function(s).

Female sex was identified as an independent factor associated with patella resurfacing. This may be explained by the pattern and type of arthritis, which may result in

**Table 2** Logistic regression analysis assessing for factors associated with a patient receiving a patella resurfacing as part of a TKA

| Demographic | Descriptive | Odds ratio | 95% CI | | *p*-value |
|---|---|---|---|---|---|
| | | | Lower | Upper | |
| Gender (M/F) | Male | Reference | | | |
| | Female | 1.53 | 1.30 | 1.79 | **< 0.001** |
| Mean age* | | 1.00 | 0.99 | 1.01 | 0.909 |
| BMI | Under | 0.47 | 0.09 | 2.49 | 0.374 |
| | Normal | Reference | | | |
| | Over | 1.10 | 0.85 | 1.42 | 0.465 |
| | Obese 1 | 0.99 | 0.77 | 1.28 | 0.959 |
| | Obese 2 | 0.80 | 0.58 | 1.10 | 0.169 |
| | Obese 3 | 1.10 | 0.76 | 1.58 | 0.624 |
| ASA grade | 1 | Reference | | | |
| | 2 | 1.16 | 0.89 | 1.51 | 0.278 |
| | 3 | 1.12 | 0.81 | 1.55 | 0.488 |
| | 4 | 1.32 | 0.18 | 9.60 | 0.784 |
| TKA design | CR | Reference | | | |
| | PS | 6.87 | 5.71 | 8.27 | **< 0.001** |
| Oxford Score* | Full | 1.02 | 0.99 | 1.04 | 0.168 |
| | Q3 | 1.06 | 0.94 | 1.19 | 0.327 |
| | Q5 | 0.85 | 0.75 | 0.96 | **0.011** |
| | Q7 | 0.94 | 0.85 | 1.04 | 0.247 |
| | Q12 | 0.87 | 0.78 | 0.98 | **0.017** |
| EQ5D* | | 1.42 | 0.99 | 2.02 | 0.052 |

Statistically significant values are indicated in bold

*Odds ratio change for each year or point change in age or score, respectively. An odds ratio above zero means the risk increases with an increase in the variable and vice versa

**Table 3** Post-operative outcome measures and the difference relative to pre-operative scores for all patients according to group

| Functional Measure | Patella resurfacing | | | | Difference | 95% CI | | *p*-value* |
|---|---|---|---|---|---|---|---|---|
| | No ($n = 1669$) | | Yes ($n = 1453$) | | | | | |
| | Mean | SD | Mean | SD | | Lower | Upper | |
| Pre-operative OKS | 20.8 | 8.0 | 20.6 | 7.9 | 0.1 | − 0.4 | 0.7 | 0.599 |
| 1 year post-operative OKS | 36.4 | 9.3 | 36.5 | 9.3 | 0.1 | − 0.5 | 0.8 | 0.661 |
| Difference | 15.6 | 9.7 | 15.9 | 9.7 | 0.3 | − 0.4 | 1.0 | 0.394 |
| 95% CI | 15.1–16.1 | | 15.4–16.4 | | | | | |
| *p*-value** | < 0.001 | | < 0.001 | | | | | |
| 2 year post-operative OKS | 36.9 | 9.7 | 37.0 | 9.5 | 0.1 | − 0.6 | 0.8 | 0.725 |
| Difference | 16.1 | 9.8 | 16.3 | 9.8 | 0.3 | − 0.4 | 1.0 | 0.441 |
| 95% CI | 15.6–16.5 | | 15.8–16.8 | | | | | |
| *p*-value** | < 0.001 | | < 0.001 | | | | | |

**t*-test

***Paired *t*-test

**Table 4** Multivariable linear regression analysis to identify pre-operative independent predictors of 1 year ($R^2 = 0.16$) and 2 year ($R^2 = 0.17$) post-operative OKS

| Demographic | Descriptive | 1-year OKS | | | | 2-year OKS | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Mean change | 95% CI | | *p*-value | Mean change | 95% CI | | *p*-value |
| | | | Lower | Upper | | | Lower | Upper | |
| Patella resurfacing | No | Reference | | | | Reference | | | |
| | Yes | 0.2 | – 0.4 | 0.8 | 0.469 | 0.2 | – 0.4 | 0.8 | 0.493 |
| Gender (M/F) | Male | Reference | | | | Reference | | | |
| | Female | – 0.5 | – 0.1 | 1.2 | 0.121 | – 0.9 | – 1.6 | – 0.2 | **0.010** |
| Mean age* | | – 0.04 | – 0.08 | – 0.00 | **0.044** | – 0.06 | – 0.09 | – 0.02 | **0.007** |
| BMI | Under | 1.2 | – 5.2 | 7.6 | 0.709 | 1.1 | – 5.5 | 7.7 | 0.752 |
| | Normal | Reference | | | | Reference | | | |
| | Over | – 0.3 | – 1.3 | 0.8 | 0.641 | – 0.1 | – 1.2 | 1.0 | 0.803 |
| | Obese 1 | – 1.3 | – 2.3 | – 0.2 | **0.021** | – 0.9 | – 2.0 | 0.3 | 0.132 |
| | Obese 2 | – 2.9 | – 4.2 | – 1.5 | **< 0.001** | – 2.8 | – 4.2 | – 1.4 | **< 0.001** |
| | Obese 3 | – 1.6 | – 3.1 | – 0.0 | **0.044** | – 1.7 | – 3.2 | – 0.1 | **0.038** |
| ASA grade | 1 | Reference | | | | Reference | | | |
| | 2 | – 0.9 | – 2.0 | 0.2 | 0.128 | – 0.7 | – 1.8 | 0.5 | 0.246 |
| | 3 | – 1.6 | – 3.0 | – 0.3 | **0.019** | – 1.5 | – 2.9 | – 0.1 | **0.036** |
| | 4 | – 4.1 | – 12.5 | 4.4 | 0.344 | – 3.3 | – 12.0 | 5.3 | 0.451 |
| TKA design | CR | Reference | | | | Reference | | | |
| | PS | 1.1 | 0.4 | 1.9 | **0.001** | 0.8 | 0.0 | 1.5 | **0.040** |
| Oxford score* | Full | 0.3 | 0.2 | 0.4 | **< 0.001** | 0.3 | 0.2 | 0.4 | **< 0.001** |
| | Q3 | 0.7 | 0.2 | 1.2 | **0.006** | 0.6 | 0.1 | 1.1 | **0.016** |
| | Q5 | – 0.2 | – 0.7 | 0.3 | 0.351 | – 0.1 | 0.6 | 0.4 | 0.653 |
| | Q7 | 0.3 | – 0.1 | 0.7 | 0.203 | 0.2 | – 0.3 | 0.6 | 0.431 |
| | Q12 | – 0.0 | – 0.5 | 0.4 | 0.869 | 0.2 | – 0.3 | 0.7 | 0.439 |
| EQ5D* | | 3.1 | 1.8 | 4.5 | **< 0.001** | 2.5 | 1.1 | 3.9 | **0.001** |

Statistically significant values are indicated in bold

*Mean change for each year or point change in age or score, respectively

**Table 5** Post-operative outcome measures and the difference relative to pre-operative scores for all patients according to group

| Functional measure | Patella Resurfacing | | | | Difference | 95% CI | | *p*-value* |
|---|---|---|---|---|---|---|---|---|
| | No ($n = 1673$) | | Yes ($n = 1454$) | | | | | |
| | Mean | SD | Mean | SD | | Lower | Upper | |
| Question 3: Have you had any trouble getting in and out of the car or using public transport because of your knee? | | | | | | | | |
| Change at 1 year | 0.87 | 1.08 | 0.90 | 1.05 | 0.04 | – 0.04 | 0.11 | 0.351 |
| Change at 2 years | 0.92 | 1.06 | 0.93 | 1.07 | 0.01 | – 0.07 | 0.08 | 0.847 |
| Question 5: After a meal (sat at a table), how painful has it been for you to stand up from a chair because of your knee? | | | | | | | | |
| Change at 1 year | 1.29 | 1.09 | 1.36 | 1.07 | 0.07 | – 0.01 | 0.15 | 0.072 |
| Change at 2 years | 1.37 | 1.08 | 1.41 | 1.08 | 0.04 | – 0.04 | 0.11 | 0.318 |
| Question 7: Could you kneel down and get up again afterwards? | | | | | | | | |
| Change at 1 year | 0.79 | 1.29 | 0.77 | 1.26 | – 0.02 | – 0.11 | 0.07 | 0.678 |
| Change at 2 years | 0.79 | 1.29 | 0.75 | 1.26 | – 0.03 | – 0.12 | 0.05 | 0.449 |
| Question 12: Could you walk down a flight of stairs? | | | | | | | | |
| Change at 1 year | 1.15 | 1.09 | 1.24 | 1.24 | 0.09 | 0.01 | 0.17 | **0.019** |
| Change at 2 years | 1.17 | 1.11 | 1.23 | 1.09 | 0.07 | – 0.01 | 0.14 | 0.094 |

Statistically significant values are indicated in bold

**t*-test

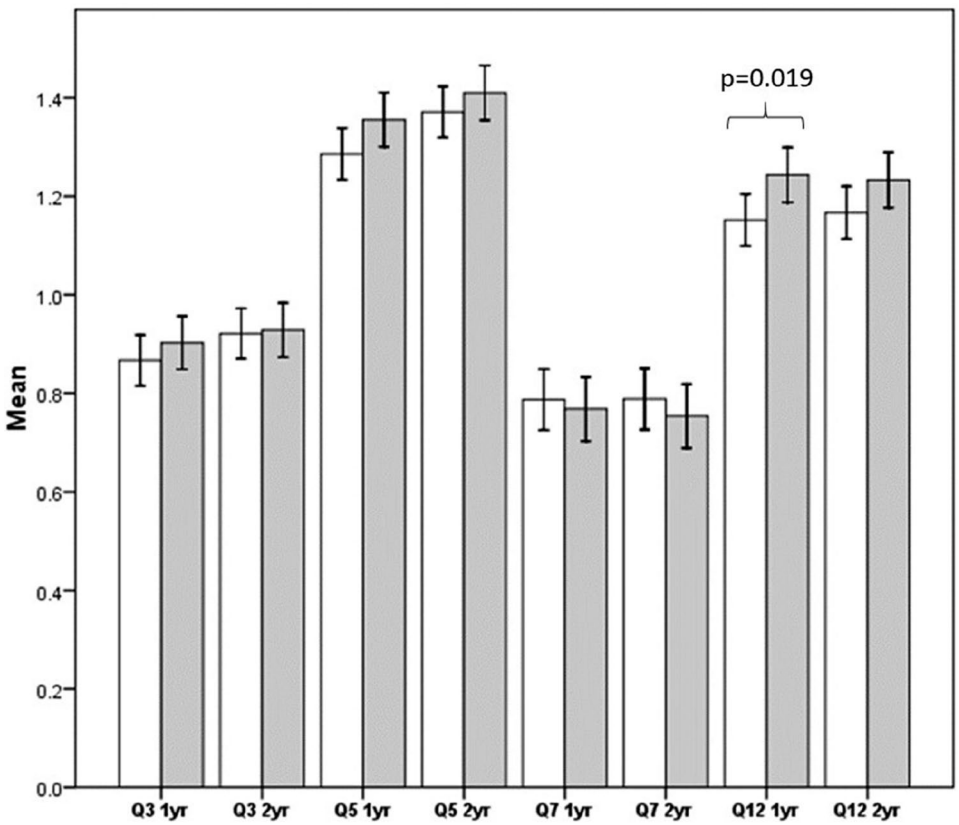


**Fig. 3** Bar chart illustrating the 1- and 2-year postoperative mean improvement for questions 3, 5, 7 and 12 of the Oxford knee score according to whether the patella was resurfaced (grey) or not (white). The error bars represent the 95% confidence intervals

**Table 6** Rate of satisfaction at following TKA according to group

| | Patella resurfacing | | Odds ratio | 95% CI | | *p*-value |
|---|---|---|---|---|---|---|
| | No (%) | Yes (%) | | Lower | Upper | |
| 1 year | | | | | | |
| Satisfied | 1501 (92.95) | 1281 (91.63) | 0.83 | 0.64 | 1.09 | 0.178 |
| Not Satisfied | 114 (7.05) | 117 (8.37) | | | | |
| Missing | 54 | 55 | | | | |
| 2 years | | | | | | |
| Satisfied | 1444 (92.39) | 1270 (92.30) | 0.99 | 0.75 | 1.29 | 0.927 |
| Not satisfied | 119 (7.61) | 106 (7.70) | | | | |
| Missing | 106 | 77 | | | | |

*Chi-square test

When adjusting for confounders

Sat 1 year patella 0.83 (0.63–1.09, $p=0.180$)

Sat 2 years patella 0.98 (0.74–1.29, $p=0.891$)

symptomatic dysfunction of the biomechanics of the PFJ. Female sex is associated with lateral [39] and PFJ arthritis in addition to inflammatory arthritis [40], all of which may influence a surgeon's choice to proceed with patella resurfacing. PFJ dysfunction is typically more common in patients with lateral compartment arthritis and valgus deformity [41] and therefore may be more likely to benefit from patella resurfacing. The associated dysfunction in the PFJ is supported by the increased difficulty in stair descent identified in the current study, with previous biomechanical studies showing increased PFJ pressure on such activity [42, 43]. In patients where patella resurfacing was employed, the ability to descend stairs was significantly greater than in patients that did not undergo resurfacing. This may support the potential benefit of patella resurfacing on specific function relating to the PFJ, which may not be recognised in current knee-specific scoring measures.

**Table 7** Change in the Oxford knee score at 1 year for patients undergoing patella resurfacing and for those that did not according to patient demographics and pre-operative functional scores

| Demographic | Descriptive | Patella resurfacing | | Difference | 95% CI | | *p*-value* |
|---|---|---|---|---|---|---|---|
| | | No | Yes | | Lower | Upper | |
| Gender | Male | 14.8 (9.5) | 14.8 (9.50 | 0.0 | – 1.1 | 1.1 | 0.999 |
| | Female | 16.2 (9.8) | 16.4 (9.7) | 0.2 | – 0.7 | 1.1 | 0.711 |
| Mean age | < 60 | 15.4 (10.3) | 17.3 (9.5) | 1.9 | – 0.5 | 4.3 | 0.128 |
| | 60–70 | 16.1 (9.6) | 16.8 (9.4) | 0.7 | – 0.4 | 1.9 | 0.223 |
| | > 70 | 15.4 (9.6) | 15.2 (9.8) | 0.1 | – 0.7 | 1.0 | 0.758 |
| BMI (kg/m$^2$: mean, SD) | Under | | | | | | |
| | Normal | 15.2 (9.7) | 17.0 (9.9) | 1.7 | – 0.4 | 3.9 | 0.108 |
| | Over | 15.7 (9.0) | 15.7 (9.6) | 0.0 | – 1.2 | 1.1 | 0.951 |
| | Obese 1 | 15.7 (9.9) | 15.7 (9.8) | 0.0 | – 1.1 | 1.2 | 0.977 |
| | Obese 2 | 14.9 (10.0) | 15.0 (9.7) | 0.2 | – 0.2 | 2.2 | 0.867 |
| | Obese 3 | 16.7 (11.2) | 17.5 (8.9) | 0.7 | – 1.9 | 3.4 | 0.591 |
| ASA Grade | 1 | 16.6 (9.4) | 16.7 (8.7) | 0.1 | – 2.1 | 2.3 | 0.927 |
| | 2 | 15.6 (9.6) | 15.6 (9.6) | 0.0 | – 0.8 | 0.8 | 0.985 |
| | 3 | 14.8 (10.1) | 16.9 (10.4) | 2.1 | 0.2 | 4.0 | 0.032 |
| | 4 | | | | | | |
| TKA Design | CR | 15.3 (9.4) | 14.5 (9.5) | 0.8 | – 0.7 | 2.3 | 0.291 |
| | PS | 15.9 (10.0) | 16.1 (9.7) | 0.2 | – 0.6 | 1.1 | 0.630 |
| Oxford Score | < 21 | 19.3 (10.0) | 19.3 (10.1) | 0.1 | – 0.9 | 1.1 | 0.884 |
| | ≥ 21 | 12.0 (7.8) | 12.5 (7.9) | 0.5 | – 0.3 | 1.3 | 0.210 |
| Q3 | 2–4 | 14.3 (8.9) | 15.0 (9.1) | 0.6 | – 0.1 | 1.3 | 0.088 |
| | 0 and 1 | 19.9 (10.8) | 19.3 (10.9) | 0.7 | – 1.0 | 2.3 | 0.419 |
| Q5 | 2 to 4 | 13.4 (8.6) | 13.9 (8.8) | 0.5 | – 0.2 | 1.3 | 0.175 |
| | 0 and 1 | 19.1 (10.3) | 18.9 (10.2) | 0.2 | – 0.9 | 1.4 | 0.690 |
| Q7 | 2 to 4 | 11.8 (8.2) | 11.8 (8.1) | 0.0 | – 1.2 | 1.2 | 0.968 |
| | 0 and 1 | 16.8 (9.8) | 17.1 (9.7) | 0.2 | – 0.6 | 1.0 | 0.564 |
| Q12 | 2 to 4 | 13.7 (8.9) | 13.9 (8.9) | 0.2 | – 0.6 | 1.0 | 0.604 |
| | 0 and 1 | 19.3 (10.1) | 19.5 (10.0) | 0.1 | – 1.1 | 1.3 | 0.818 |
| EQ5D | **< 0.5** | 18.8 (10.1) | 18.9 (10.4) | 0.2 | – 1.0 | 1.4 | 0.754 |
| | **≥ 0.5** | 13.6 (8.8) | 14.1 (8.7) | 0.5 | – 0.2 | 1.3 | 0.180 |

Statistically significant values are indicated in bold

*Unpaired *t*-test

**Test not performed due to limited patient numbers

A novel aspect of this study was the aim to identify specific patient factors that were associated with a functional advantage when patella resurfacing was undertaken according to the OKS. No specific indication was identified, however, that offered a clinically significant advantage. This would suggest to simply selectively resurface the patella using the factors included in the current study would not offer any advantage to the patient's functional outcome. A recent survey of members of the British Knee Society demonstrated that 39% of surgeons selectively resurface the patella, which was influenced by numerous factors including the condition of the patella cartilage [44]. One of the potential reasons the current study was not able to demonstrate a difference in outcome may be due to selection bias, with surgeons selecting patients that may have an improved functional outcome from patella resurfacing when using criteria such as patella cartilage loss. It therefore could be argued that if those patients that underwent patella resurfacing had not have done so their outcome may have been significantly worse. However, a recent study assessing the influence of patella cartilage loss did not identify a significant difference in functional outcome according to grade or pattern loss that was assigned at the time of surgery [16].

There were limitations to this study. It was a retrospective analysis of prospectively collected data and not randomised. The duration of follow-up was short, although 2-years is likely to be adequate as the OKS has been shown to peak at 2 years before steadily declining [38]. Further mid-term analysis at 5 years could be undertaken when the data are available. Severity of PFJ OA either by radiograph or

intra-operative observation was not assessed. Not all patients had pre-operative skyline radiographs, and assessment of PFJ OA on lateral radiographs alone is limited. Therefore, including this assessment would not be consistent, and furthermore, Cho et al. have already demonstrated that pre-operative PFJ OA grading from radiographs does not correlate with clinical outcomes [15]. Holland et al. have also shown that the degree of patella cartilage loss intra-operatively does not correlate with PROMS [16]. The pattern of arthritis, either varus or valgus alignment, was not assessed nor the pathology; osteoarthritis or rheumatoid arthritis. Surgeons' attitudes towards resurfacing were also not assessed. Not all patients had complete post-operative PROMS and were hence excluded. However, it has been shown that patients lost to follow-up do not demonstrate inferior PROMS, and hence, this is unlikely to have affected our results [45]. There are limitations in using the OKS to assess PFJ function, and future studies assessing this topic should consider a different outcome measure, or consider developing a novel, validated PFJ scoring system.

One of the main strengths of this study is the robustness of the data collection. There were 3122 patients included in the study with complete pre-op, 1-year and 2-year outcome scores. The substantial number of patients, surgeons and various implants used in this study could represent a general UK orthopaedics practice and so the results are generally applicable. The study was sufficiently powered using a MCID of 5 for the OKS to detect a difference in techniques if such a difference existed. Based on this single-centre, retrospective study, there is no clinically significant difference in OKS between resurfacing the patella or not for primary TKA. Stair descent may be improved with resurfacing although current patient-reported outcome measures are inadequate to assess whether this is clinically relevant.

In conclusion, patella resurfacing as part of TKA was not associated with a clinically significant improvement in knee-specific outcome according to the OKS. Female sex, those receiving a PS implant and those patients with difficulty standing from a chair or walking downstairs were more likely to undergo patella resurfacing. No specific indications for patella resurfacing were identified that offered an improved outcome, but when it was undertaken there was a greater improvement in the ability to descend stairs.

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**Availability of data and material** Data are available on request to the corresponding authors should it be required, but this would have to be authorised by the study centre audit team.

## Declarations

**Conflict of interest statement** The authors declare no conflicts of interest.

**Ethics approval and consent to participate** There was no additional patient contact, and as such, this project was performed as a service evaluation without the need for formal ethical approval. The project was registered with the institutions audit department and was conducted in accordance with the Declaration of Helsinki and the guidelines for good clinical practice.

**Consent for publication** Only anonymous data were analysed and used in this study in accordance with the audit department at the study centre.

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