Selective patellar resurfacing with or without denervation as the ultimate answer: current concepts

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Received 30 July 2016
Revised 4 October 2016
Accepted 4 October 2016
Published Online First 24 October 2016

ABSTRACT

Management of the patella during primary total knee arthroplasty remains an unanswered question. Internationally, there is significant variation in the approach to resurfacing with some geographic regions resurfacing almost universally, and other regions rarely resurfacing. This difference in preference is a result of the different geographic locations, and is influenced by where the surgeons were trained, what was taught during their training, their patients' patellae profiles, financial condition and hospital policy where the surgeons practise. In this current concepts review, we investigate where we are now with patellar resurfacing during total knee arthroplasty from an international perspective, and the differences in outcomes between resurfaced and non-resurfaced patellae. In the end, the decision to resurface or not to resurface remains at the surgeon's discretion and is highly influenced by both medical and non-medical reasons. This review includes an alternative method to address anterior knee pain, which can be an additional management option apart from resurfacing or non-resurfacing for patients where patellar resurfacing is not a viable option, such as in very thin patellae. Moreover, we will also describe other variables that may play a role in causing persistent anterior knee pain, for instance soft tissue imbalance around the patella or improper positioning of the components. It may be important to address these factors to prevent undesirable postoperative outcomes.

INTRODUCTION

The appropriate management of the patella during primary total knee arthroplasty (TKA) remains debatable. The earliest knee replacements focused entirely on the tibiofemoral joint. The patellofemoral joint was not addressed in the first generation of knee arthroplasty, resulting in significant complications with the extensor mechanism and patellofemoral joint. These complications were typically addressed with patellectomy or, in severe cases, fusion. With the success of the first generation of knee arthroplasty and recognition of significant complications with the patellofemoral joint, advances were made in joint design, including more attention to the patella.[1] The addition of a trochlear flange to the femoral component to accommodate the native patella improved functional outcomes. The next major design advancement occurred in the 1980s with the introduction of resurfacing. However, since patellar resurfacing was accepted as a crucial portion of TKA, a unique set of complications was identified. The metal backed patella was introduced during this time, and resulted in catastrophic failures.[2 3] Historically, the patella accounted for up to 50% of total knee replacement failures in the 1980s and 1990s.[4] This led to significant reconsideration of the necessity of patellar resurfacing. Resurfacing of the patellofemoral articulation poses unique challenges due to its high peak stresses, up to 20 times the body weight and small surface and contact area.[5] The debate over how to address the patella has continued for three decades (box 1).

INTERNATIONAL PERSPECTIVE

The controversy in patella resurfacing is demonstrated by an Internationally wide diversion of approaches to the patellae during TKA (see figure 1). In North America, >90% of surgeons routinely resurface the patella. Vielgut *et al* published an interesting review of eight European joint registries in International Orthopedics in 2013 and noted wide differences in patellar resurfacing. In Scandinavian countries, there are dramatic differences in the approach to the patella. The Danish joint registry shows that 76% of patellae are resurfaced, whereas in Norway and Sweden only 2% are resurfaced. Australian surgeons resurface ~50% of patellae. The English and Welsh registry showed a 30% rate of patellar resurfacing. The Portuguese registry showed a 65% resurfacing rate. In New Zealand, 30% are resurfaced and in Canada, almost 60% are resurfaced. Reviewing the revision rates of these same registries, there appears to be no correlation with patellar resurfacing.[6]

Fraser *et al* recently reviewed international registries to determine if the rates of resurfacing had changed significantly from 2004 to 2014. Data were reviewed from seven national joint registries. Norway continued to have the lowest rate of resurfacing at 4%. Over that time frame, the rate of

Box 1 Current concepts

- The patella resurfacing rate in the USA is 82%, while only 35% of the patella are resurfaced outside the USA.
- Research papers, reviews and meta-analysis papers have reported similar outcomes for routine resurfacing and non-resurfacing.
- Decisions to resurface or not to resurface are also influenced by factors outside clinical conditions, such as where the surgeons were trained, hospital policy and financial condition.

To cite: Cameron-Donaldson ML, Ifran NN, Budhiparama NC. *JISAKOS* 2016;**1**:311–315.

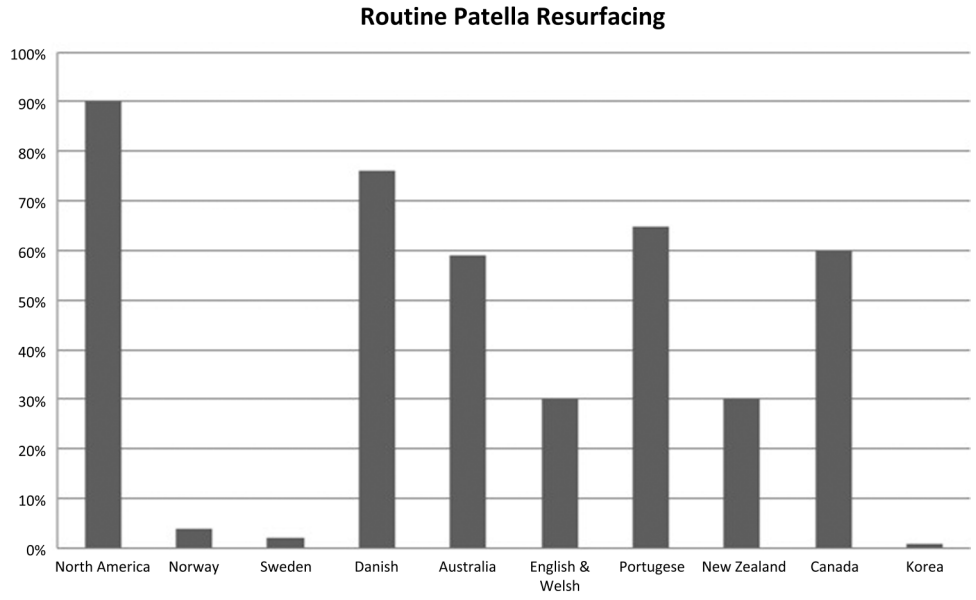

Figure 1 International distribution of patellar resurfacing based on results reported by Vielgut[6], Fraser[7] and Koh.[9]

resurfacing in Sweden decreased from 15% to 2%. Australia showed some increase in the rate of resurfacing over this 10-year span, increasing from 44% to 59%. The USA continued to have the highest rate of resurfacing at 82%. A comparison of the USA versus the non-US registries found that in 2010, only 35% of total knee replacements performed outside the USA resurfaced the patellae. They concluded that worldwide trends in resurfacing are essentially unchanged over the past decade.[7] If this review had included registries from Asian countries, then the percentage of routine patellar resurfacing outside of the USA would be <35%.

In Asia, patellar resurfacing is less common. The common attitude is to either never resurface or to selectively resurface the patellae. Since patella resurfacing is very technically dependent, surgeons who had trained in a centre which never resurfaced will then carry out this practice in his/her clinic. On the other hand, surgeons who practise in routine resurfacing centres will then choose to selectively resurface their patients. This is mainly attributed to the smaller stature and thin patellae of Asian patients. Another contributing factor is the additional cost involved in resurfacing the patella. Since different national healthcare or private insurance provide different benefit coverage, the extra expense would prevent the practice of routine patella resurfacing. Patella resurfacing is commonly performed in patients with rheumatoid arthritis or those with a severely damaged cartilage, provided that the patella bone size and thickness allows for the procedure.[8]

A multicentre study in Korea reported that from their data of 20 234 primary TKAs and 643 revision TKAs performed at 19 institutions, only 1% of all arthroplasties were resurfaced.[9] However, the objective of the study did not specifically investigate the difference in outcome between resurfaced and non-resurfaced knees.

A study by Feng *et al*[10] in China found no significant differences in long-term survivorship between a group of 176 resurfaced patellae and 70 unresurfaced patellae after 10 years follow-up. It concluded that patellar non-resurfacing can be advisable in primary knee replacement due to osteoarthritis and selective resurfacing can be implemented for patients with rheumatoid arthritis. Since it is difficult to find an established national registry or a good prospective randomised trial performed in Asian countries, many surgeons still hesitate to perform routine patella resurfacing.

CURRENT APPROACHES TO PATELLAR MANAGEMENT IN TKA

As of 2016, there are three camps in the approaches to patellar resurfacing: routine resurfacing, no resurfacing and selective resurfacing.

Routine resurfacing

Proponents of routine resurfacing cite reduced postoperative anterior knee pain, higher patient satisfaction, better overall function and low complication rates. Revision rates for resurfaced patellae have decreased from 50% in the 1980s and early 1990s to ~10% in the current literature.[11–13] Complications associated with resurfacing include patella fracture, maltracking, soft tissue impingement, patellar ligament rupture, polyethylene fracture, polyethylene wear, component loosening and component dissociation. In total, the risk of all of these complications is low with most studies citing individual complication risks in the 1–5%.[11 14–16]

No resurfacing

Clinicians who favour retaining the native patellae argue that patients with or without resurfacing have similar outcomes. The reported rate of secondary resurfacing due to persistent anterior knee pain is 10–12% based on multiple studies.[17–20] The non-resurfacing camp claims preservation of patellar bone, more normal patellofemoral kinematics and ease of resurfacing if persistent anterior knee pain develops. Furthermore, they emphasise the avoidance of postoperative complications attributable to resurfacing.[20 21 12 17] More recently, the non-resurfacing group seems to have split with most still advocating no resurfacing and a smaller subset advocating no resurfacing and patellar denervation at the time of primary TKA.

Selective resurfacing

Proponents of selective resurfacing attempt to identify patients at risk for persistent anterior knee pain or poor clinical

function. Broad guidelines for patellar resurfacing are preoperative anterior knee pain, inflammatory arthritis, crystalline disease and evidence of Outerbridge grade IV changes, patellar maltracking, subluxation or dislocation.[17 22–24] Selective resurfacing studies have documented survival rates up to 97.5% at 10 years.[20 23 25–28]

CURRENT LITERATURE

Routine resurfacing versus non-resurfacing

Since the patellar resurfacing discussion has been ongoing for over 30 years, there are literally hundreds of articles on the topic. The studies, reviews and meta-analysis published in the past 5 years continue to be inconclusive. In 2011, Breeman *et al* published a randomised controlled trial of 1715 patients randomised to resurfacing versus non-resurfacing with a 5-year follow-up and found no difference in the functional outcomes, reoperation rate or total healthcare costs. Two per cent of the patients who were in the non-resurfaced group required secondary resurfacing within 5 years, and 1% of the patients undergoing resurfacing sustained a patellar-related complication that required revision surgery.[29] Pavlou *et al*[30] performed a meta-analysis, also published in 2011, which showed that patellar resurfacing did not significantly affect anterior knee pain or functional outcomes; however, there was a slightly higher reoperation rate in the non-resurfaced group.

In 2012, Beaupre *et al*[31] reported the results of another randomised controlled trial with a 5–10 year follow-up and showed no difference between the resurfaced and non-resurfaced groups. A meta-analysis in 2012 published by Pilling *et al* found that patellar resurfacing decreased the risk of reoperation due to patellofemoral pain, but otherwise no difference in patient satisfaction, pain or function was noted between the two groups. However, it is important to note that in the resurfaced group, anterior knee pain was 11% less than in the non-resurfaced group.[32]

Another meta-analysis, published in 2013 by Chen *et al*, reported that the risk of reoperation due to patellofemoral pain was reduced by 4% in the patellar resurfacing. This means that one would have to resurface 25 patellae to prevent one reoperation. There was no difference in the two groups with regard to anterior knee pain, knee pain score and knee function score. However, in a follow-up no less than 5 years, a difference was found between the two groups in the Knee Society Score, indicating that resurfacing patellae in patients may make a difference in long-term follow-up.[28]

Secondary patellar resurfacing

The literature has shown that secondary patellar resurfacing (SPR) is a viable option for non-resurfaced patellae in case of persistent anterior knee pain. In 2015, Scheurer *et al*[33] evaluated mid-term clinical outcomes after SPR for persistent anterior knee pain in a retrospective study and found that secondary resurfacing led to patient satisfaction in a relatively large number of patients, especially in those without patellar tilts. In a retrospective study of 46 patients who underwent secondary resurfacing after persistent anterior knee pain following primary TKA, Toro-Ibarguen *et al*[34] found that despite improvement of the Knee Society Score, many patients continued to suffer anterior knee pain and were dissatisfied after the procedure. Moreover, a study by Leta *et al* on SPR for painful unresurfaced knees from the Norwegian Arthroplasty Registry in 2016 found that the long-term survival rate of the prosthesis after SPR was satisfactory although not as good as primary knee replacement. Although the patients' health-related quality of life improved significantly following SPR, more than 30% of patients were dissatisfied based on the patient-reported outcome measures (PROM) data.[35]

Most recently, van Jonbergen *et al* also performed a systematic review on patient satisfaction and functional outcomes following SPR. In total, 15 studies (232 patients) met the criteria and 36% of patients were dissatisfied with the outcome of SPR despite a statistically significant improvement noted in all studies that reported functional outcome. Result of these studies showed that patient satisfaction has no correlation with functional outcome and therefore SPR should be performed only if improved functional outcomes are the desired end points and not patient satisfaction.[36]

Another risk factor to be considered regarding persistent anterior knee pain after SPR is whether there is another possible cause of anterior knee pain (AKP) such as malrotation of either the femoral or tibial component. Bhattee *et al* found that of 21 patients reviewed, 61% were dissatisfied after SPR procedures. The mean femoral internal rotation in the satisfied group was 0.92° compared to 2.88° in the dissatisfied group. The authors concluded that investigations are needed in patients suffering from AKP post-TKA, especially in the non-resurfaced group, to eliminate other possible underlying causes of AKP prior to undergoing secondary resurfacing. In case the problem is component malrotation, revision knee replacement may lead to better satisfaction than secondary resurfacing.[37]

Financial implication

Several studies have been carried out to justify the extra cost of patellar resurfacing. The Knee Arthroplasty Trial (KAT)[38] conducted by National Health Services (NHS) in the UK concluded that patellar resurfacing is more cost-effective in a group of patients aged below 70 years. It found that after 10 years, the patellar resurfacing group is associated with lower cost and better outcomes. However, if the non-resurfacing group does not perform late secondary resurfacing in patients with anterior knee pain after primary arthroplasty, then the cost-benefit will decrease. Moreover, this paper also found that with time, the patellar complications in the resurfaced group also increased.

Meijer and Dasa analysed the financial implications of resurfacing versus non-resurfacing using the data from randomised controlled trials in the past decade and actual costs collected from Medicare reimbursement rates. They found that the expected value of primary knee replacement with patellar resurfacing was $227.92 lower than those of non-resurfaced knees at 5 years. The savings remain valid as long as patellofemoral revision rates after resurfaced patellae remain below 3.54% and patellofemoral revision rates after non-resurfaced patellae remain above 0.77%. From the Medicare perspective over a mid-term period, patellar resurfacing is the optimal financial strategy.[39]

Implant design and kinematics

From a kinematic standpoint, to resurface or not to resurface the patella also remains contentious. A study conducted by Lee *et al*[40] found that 31% of patients who underwent knee replacement with patellar resurfacing had preoperative patella thickness <21 mm, and this group of patients will have poorer gain in range of motion at 1-year follow-up. Residual patella thickness <12 mm also showed a poorer result at 1-year follow-up even in the absence of patellar fracture or implant loosening. Conservative cutting resulting in a 1 mm increase in patellar thickness was found to also have inferior clinical results.

To answer which implant design is more patella friendly, a New Zealand Joint Registry Study conducted by Wyatt *et al*,[41]

which lasted 11 years, showed that revision surgery to resurface an unresurfaced patella in primary TKR occurred at a higher rate in a fixed bearing posterior stabilised design compared with either a fixed bearing cruciate retaining or mobile bearing design.

As an alternative to a resurfaced patella, in 2012, Liu *et al*[42] performed a prospective randomised trial comparing patellar resurfacing and patellar reshaping. In the patellar reshaping group, the lateral patella and surrounding osteophyte was partially removed and the patella was trimmed to match the femoral trochlea. They found no significant difference between the two groups in terms of the Knee Society pain score, Knee Society function scores and anterior knee pain rate after 7 years of follow-up. Thus, the paper suggested that in the non-resurfacing group, the patella is reshaped so that it will still retain the bone stock and secondary resurfacing can still be performed when necessary.

Patellar denervation

Most recently, several studies have been published looking at patellar denervation as an option versus resurfacing but also showing a variation in results. In 2012, Altay *et al* investigated the effect of denervation on 35 bilateral knee replacement without patellar resurfacing. Denervation was performed on one knee but not on the contralateral knee. Although the follow-up was rather short at only 2 years, the authors found a significant difference on all scores (KSS, VAS and range of motion) comparing before to after surgery in the denervation group.

In 2014, Li *et al* published a meta-analysis investigating whether patellar denervation with electrocautery could reduce the risk of anterior knee pain. Their study showed that patients who underwent patellar denervation had less anterior knee pain, higher patellar functional scores and better knee function compared to patients without denervation.[43] Most recently, Arirachakaran *et al* performed a meta-analysis of patellar resurfacing, non-resurfacing and patellar denervation. They found that compared to patellar non-resurfacing, patellar denervation patients had improved pain visual analogue scores and knee society scores. Patellar denervation also showed superior outcomes in knee function scores compared to patellar resurfacing.[44]

On the other hand, Cheng *et al* published a meta-analysis comparing patients without patellar resurfacing and patients who underwent patellar denervation with electrocautery. They found no significant difference in anterior knee pain between the two groups. Improvement was noted in patellar scores and Knee Society Scores in the electrocautery group. There was no difference in complications between the two groups.[45] Another meta-analysis by Fan *et al* in 2015 showed similar results to the Cheng study.[46]

Interestingly, van Jonbergen *et al*, who did a randomised controlled trial of circumpatellar electrocautery in TKA without patellar resurfacing, found that at the 3.7-year follow-up, the improvement in clinical outcomes previously found at the 1-year follow-up was not maintained at the 3.7-year follow-up.[47 48] This finding calls for a longer follow-up term in clinical trials before any conclusion can be drawn for a surgical technique.

CONTROVERSY/CONSENSUS

The biggest problem in the resurfacing versus non-resurfacing debate is not understanding why some patients have postoperative anterior knee pain and others do not. This is the driving force behind the selective resurfacing argument. In 2001, Barrack *et al* found that 28% of patients with resurfaced patellae suffered from anterior knee pain postoperatively. These patients had not reported preoperative anterior knee pain. About 9% of patients who reported preoperative anterior knee pain had continued pain postoperatively despite resurfacing. In the non-resurfaced group, 23% reported anterior knee pain preoperatively and continued to report similar pain postoperatively; 14% of the non-resurfaced group developed new anterior knee pain postoperatively.[14] In his review, Nikolau *et al* concluded that although patellar resurfacing is a common practice in some areas, it is not supported enough by high-quality trials over the past decade. Despite some benefits have been documented, they are not strong enough to justify routine patellar resurfacing by all orthopaedic surgeons, especially when there are other options that are more consistent in reducing anterior knee pain post knee arthroplasty.

More recently, data on patellar denervation show some possible improvement over strict non-resurfacing and the resurfacing group. Despite the variation in outcomes with and without resurfacing +/− denervation, there is some consensus regarding patients who should undergo resurfacing at the time of primary TKA; these include patients with inflammatory arthritis, severe patellar deformity or eburnation and the presence of crystalline disease.

CONCLUSIONS

Despite 30 years of research into patellar resurfacing, answers remain elusive. North American surgeons continue to be the most aggressive in patellar resurfacing, with Europeans being less likely to resurface and Scandinavians being split on the topic. Asian surgeons tend to be more conservative and therefore rarely routinely resurface due to the different patient profile from the Western surgeons and also due to economic constraints. Most data point to similar outcomes with resurfaced and non-resurfaced patellae; however, the risk of reoperation for anterior knee pain persists and is more common in non-resurfaced patellae. Patellar denervation may offer an alternative to both of these techniques.

Ultimately, the answer will most likely reside in selective resurfacing with or without denervation; however, the criteria for selective resurfacing still requires more research to determine which patients are at highest risk for postoperative anterior knee pain and would benefit from primary resurfacing. Several

Box 2 Future perspectives

- The battle between to resurface or not to resurface will continue.
- The higher reoperation rate in non-resurfaced patella might be due to hesitancy to perform revision surgery in the resurfaced patella with persistent anterior knee pain.
- Soft tissue balancing, patellofemoral congruence and proper component positioning may play a more important role in reducing anterior knee pain.
- Patellar denervation has shown a more consistent result in reducing anterior knee pain and can become an alternative to resurfacing or as an additional procedure.
- More research is needed to identify risk factors and preoperative variables associated with persistent anterior knee pain and patient criteria for selective resurfacing.

confounding factors may be at play in making these selection criteria elusive, including vast differences in the implant 'patellar-friendly' design, sensitivity of the knee scoring systems to determine real differences in patient outcomes, the so-called 'ceiling effect' where patients reported maximum scores during PROM that result in a bias of surgical outcome interpretation, and the vast heterogeneity in data in the large meta-analysis with different implants and different surgeons performing the knee arthroplasty. It appears as if the debate will continue for years to come, until further long-term research and analysis can bring clarity on resurfacing versus non-resurfacing for the appropriate patient (box 2).

Competing interests None declared.

Provenance and peer review Commissioned; externally peer reviewed.

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*J ISAKOS*2016 1: 311-315 originally published online October 24, 2016
doi: 10.1136/jisakos-2016-000095