Review

How to address the patella in revision total knee arthroplasty

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Abstract

Patellar issues need to be carefully addressed during any revision TKA and the surgeon often faces the question of what to do with the patella at the time of revision. The choice of treatment is often made by balancing what is technically feasible with the risk of potential complications and takes into account the reason for the revision, the type of implant (i.e., metal-backing or all-polyethylene), the duration of implantation, the fixation, the stability, the sterilization technique, the wear, the presence of osteolysis, the compatibility with the femoral component, and most importantly the remaining bone stock. The various treatment options then include retention of the patellar component, revision of the patellar component, removal of the component with retention of the patellar bony shell (patelloplasty or resection arthroplasty), excision of the patella (partial or total patellectomy), secondary resurfacing, and reconstruction/augmentation of the patellar bone stock. Isolated patellar revision is associated with a high complication rate and recurrent failure when poor patellar tracking, incongruent designs and malalignment of the femoral and tibial components exist. Retention of a well-fixed all-PE (non-oxidized) patella is advocated where possible and revision of metal-backed patella is recommended (unless well fixed with poor bone stock). In the situation of a deficient patella, patelloplasty, augmentation procedures and very rarely patellectomy are other viable options.

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1. Introduction

Patellofemoral complications occur in up to 10% of total knee arthroplasties (TKA). They are responsible for up to 50% of all revision procedures, and thus remain the most common reason for reoperation after a TKA [1–12]. Specific patellofemoral complications include patellar component wear and loosening, patellar and soft tissue impingement, patellar fracture, avascular necrosis, explained and unexplained anterior knee pain, extensor mechanism ruptures, and patellofemoral instability with or without component malpositioning [1,8–33].
The method of patellar treatment has a substantial impact on the expected clinical results following a revision TKA and the surgeon often faces the question of what to do with the patella at the time of revision [13]. The various patellar considerations during revision surgery include the reason for surgery, the type of the previous patellar implant, wear, osteolysis, loosening, femoral component compatibility, femoral component alignment, and most importantly the remaining bone stock. The various treatment options then include retention of the patellar component, revision of the patellar component, removal of the component with retention of the patellar bony shell (patellectomy or resection arthroplasty), excision of the patella (partial or total patellectomy), secondary resurfacing, and reconstruction/augmentation of the patellar bone stock. Isolated patellar revision is associated with high complication rates and recurrent failure when poor patellar tracking, incongruent designs and malfignment of the femoral and tibial components exist [15,17]. Ultimately, the choice of treatment is often made by balancing what is technically feasible with the risk of potential complications [17]. This article will discuss these treatment options available for the patellar component during a revision TKA. Other patellar issues such as exposure and component retrieval [14–17], patellar clunk [10,18] and lateral facet syndromes [10,19], rupture of extensor mechanism [10], malalignment and instability [20–25] have been detailed in detail elsewhere and will not be the focus of this review.

2. Retention of the patellar component

Retaining the patellar component is not only simple but also preserves bone stock and avoids additional complications [7]. In 30–50% of the revision TKA, the existing patellar component is well fixed and can, therefore, be retained [13,26]. However, it is important to confirm fixation intraoperatively because there have been reports of loose components despite the good radiological appearance [15]. Radiographic features associated with failures are bone-cement radiolucency, increased bone density, trabecular collapse of bone, patellar fracture and fragmentation and lateral subluxation of the residual patellar bone. Thus, it has been emphasized to remove the fibrous meniscal-like tissue that develops around the patella for proper exposure and stability assessment [16].

Barrack et al. [26] prospectively compared 34 cases with retained patellar components (22 all-polyethylene [PE] and 12 metal-backed) to 39 cases of all-PE patellar reimplantations. The indications for retention were rigid fixation radiographically and intraoperatively, normal or near normal tracking of the patella intraoperatively, minimal or no wear, a patellar component geometry compatible with the femoral component and any well-fixed metal-backed component with inadequate bone stock (less than 12 mm) for removal and reimplantation. The indications for reimplantation were tilting or maltracking based on geometric mismatch, clinical and radiological evidence of loosening or osteolysis, significant damage even in the absence of fixation, and any metal-backed component that had adequate bone to allow for removal and reimplantation. At a mean follow-up of 3 years, they found no difference between the two groups and concluded that retaining a well-fixed component with the above indications was a viable option with equivalent short term results to those obtained when the patellar component was revised.

In a retrospective study on 202 revision TKA, Lonner at al. [7] reported a 10% (21) incidence of anterior knee pain at an average of 7.3 years in whom an all-PE patellar implant was retained. However, 52% of these patients had an identifiable etiology like loosening, PE wear or delamination and the rest had osseous impingement on the femoral component or soft tissue dysfunction (impingement, scarring and subluxation). The 5% incidence of anterior knee pain that was related to bony or soft tissue impingement is much lower than 30% prevalence after patellectomy procedures [26,27]. The only risk factor for loosening and wear that was noted was the mode of PE sterilization with a gamma irradiation in air having the worse prognosis. Quantifying an acceptable amount of wear is difficult but the authors recommended retaining the implant only if there is mild deformation due to cold flow and no pitting or delamination. Another important finding in this study was that although 68% of the patella and femoral components were from different manufacturers, there was no increased propensity for maltracking, indicating that with current designs manufacturing mismatch is acceptable. This study suggests that retention of a well-fixed and well-positioned all-PE patellar component that was appropriately sterilized can yield acceptable results after revision TKA. Thus, the revision of a well-fixed all-PE patellar component which was not gamma irradiated in air is probably unnecessary [7,15,17,26].

3. Revision of the patellar component

Patellar revision optimizes the patellofemoral congruency but compromises the bone stock with an increased possibility of further complications. The most obvious need to revise a patellar component is a loose component or significant wear, although other indications may be malpositioning, maltracking, instability, or even anterior knee pain. The type of patellar component (All-PE versus metal-backed and the type of PE processing) is also an important consideration. The use of all-PE patella in primary TKA has a failure rate of less than 0.5% at 5 years [17,29] whereas metal-backed prosthesis have shown early (16–18 months) as well as late (6–8 years) failures with a rate of 6–10% [4,17,30,31].

It should also be noted that isolated revision of the patellar component in revision TKA has been shown to have higher complication rates [32,33]. Berry and Rand [32] retrospectively analyzed 41 patients who underwent isolated patellar revision. Although the Hospital for Special Surgery knee score [34] improved from a mean of 71 to 81, 14 (34%) patients had significant complications. In a similar more recent report by Leopold et al. [33], of the 40 knees which underwent an isolated revision of the patella, 15 (38%) of the patellar components failed a second time at a mean follow-up of 62 months. They emphasized paying attention to implant design and component alignment before proceeding with an isolated patellar revision.

Isolated patellar revision should be undertaken only after all possible causes of patellar failures have been considered. Elements of component alignment and surgical technique are known to contribute to patellar component failure and may be at least as important as implant design [33,35–37]. Some of the common errors in surgical technique include internal rotation of the femoral or tibial component, relative overstuffing of the anterior compartment, lateral placement of patellar component, and residual tightness of the lateral retinacular structures [33,35,37–40]. Burke et al. [41] and Koh et al. [42] have shown satisfactory mid-term outcome after revision of an isolated failed metal-backed patellar component to an all-PE component in selected patients with adequate bone stock and no major misalignment of the components.

Component design issues also affect the patellofemoral performance [20,43–49]. Some of the common design flaws shared by the unsuccessful metal-backed patellar implants include thin ultra-high molecular weight polyethylene near the edge of the metal plate, and incomplete bone ingrowth leading to shear stresses at the peg-plate junction of the cementless designs. Burke et al. [41] emphasized the role of implant design and suggested that a titanium alloy femoral component (in comparison to a chromium alloy) may be more sensitive to damage from articulating with a disassociated metal-backed patella, potentially leading to excessive metallosis and the need for extensive revision. The modern femoral design with a deep trochlear groove, more congruent patellofemoral articular geometry, and a broader contact surface on the patellar component have addressed many of these patellofemoral problems.
The presence of a well-fixed metal-backed patellar component can result in significant bone loss or patellar fracture unless removal is performed properly. In most cases removal of an all-PE component requires little more than separating it from its cement base with an oscillating saw. Once the prior component is removed, the patella should be prepared by removing the fibrous tissue and any remaining cement that is necessary. Again a high speed burr facilitates the process and minimizes fracture [16]. Finally a similarly sized or smaller all-PE component should be cemented into place using the opposite peg design of the previous implant, i.e. use a single central peg if previously a 3-peg design was used.

This attention to detail minimizes bone loss, the key determinant for further reconstructive options. If the cement or metal lugs are well fixed and will not interfere with the fixation and positioning of another patellar implant, it is acceptable to retain this rather than remove any excess bone. In certain cases, removal of metal-backed components may not be possible without extensive bone loss. Patellar bone stock should be assessed with regards to quality, quantity and location of remaining bone to determine the fixation of a new component. Whenever possible, it is always better to implant another patellar component rather than perform a patelloplasty (leaving the unresurfaced patellar bone remnant in place) as also explained later in the manuscript [17,26].

Thus based on the current literature, indications of revising a well-fixed patellar component include a metal-backed component (especially if residual bone stock would be adequate), an oxidized all-PE component (or most components that have been gamma irradiation in air), significant wear or component maltracking due to incongruous tibio-femoral rotational alignment [78]. However, if the metal-backed component has a good track record (e.g. LCS, Depuy, Johnson and Johnson, Warsaw, Indiana), the implant is well fixed with no visible wear and the bone stock is questionable, the metal-backed component should be left in situ [17,26].

4. Secondary resurfacing of the patella

There are few reported series on secondary resurfacing of the patella (resurfacing of the patella which was not resurfaced during the index TKA) and all show unfavorable results [51–55]. In a prospective randomized trial by Barrack et al. [51] of TKA with or without patellar resurfacing, 17% of the 46 unresurfaced procedures had anterior knee pain as compared to the 19% of the 47 initially resurfaced ones. Seven of the unresurfaced ones had secondary resurfacing but the pain recurred in four of five remaining patients at 5–7 years follow-up. In another retrospective study on 623 patients with primary TKA without patellar resurfacing, 20 (3.2%) underwent secondary resurfacing for chronic anterior knee pain at a mean follow-up of 36.1 months, the mean Knee Society Score (KSS) [56] for knee and function improved from 46.2 to 62.2 and 44.7 to 52.2 respectively. But only 44.4% patients reported some improvement. All patients had at least one radiological measurement outside the recommended range of alignment. Complications were encountered in six of 20 (30%) patients including fracture, loss of motion and patellar instability, and half of these required a tricompartmental revision. The authors did not recommend secondary resurfacing of the patella in all patients with anterior knee pain and suggested that alignment of the tibial and femoral component, congruency of the patellofemoral articulations and change in joint line may be important determinants of recurrent anterior knee pain. Similarly Campbell et al. [52] concluded that the outcomes of secondary resurfacing are unpredictable.

Mockford and Beverland [54] retrospectively reported on 13 of 2950 (0.4%) patellae which underwent secondary resurfacing and concluded that the success rate is poor and that patients should be carefully counseled. In a retrospective matched pair study of primary versus secondary resurfacing of the patella, Kamezis et al. [53] concluded that although significant clinical improvement was seen after secondary resurfacing, the outcome of secondary resurfacing was inferior to that expected for a similar group of patients with primary resurfacing. Further, they advocate an early secondary resurfacing, when indicated. Rand suggests not resurfacing the patella if the patella doesn’t show any vascularity at the time of revision, in addition to other criteria [28].

Thus the current literature suggests that anterior knee pain is multifactorial and may not be addressed by a secondary resurfacing procedure.

5. Retention of a patellar bony shell (patella resection arthroplasty/patelloplasty)

Although this appears to be a simple, less expensive procedure with decreased operative time, it may be complicated by maltracking, osteonecrosis, fracture, persisting stiffness, extensor lag and knee pain [27]. Pagnano et al. retrospectively reported on 31 patients who underwent patelloplasty when the patella thickness was less than 10 mm with central cavitary defects precluding adequate implant fixation [27]. At a mean follow-up of 3.5 years, the mean KSS for knee and function improved from 59 to 75 and 46 to 69 respectively. However, complications occurred in 1/6 and mild to moderate knee pain persisting in 1/3 of the patients. Laskin [16] also reported similar results at two years follow-up, but interestingly the patelloplasty group in their study had a mean flexion of 120° as compared to the 105° in remainder of the reimplantation group.

Barrack et al. [50] retrospectively compared 21 cases of patelloplasty to 92 cases with a patellar component retention or reimplantation. The indication of patelloplasty was when there was only a cortical shell of bone remaining or when the patella thickness was less than 12 mm. At a mean of 30 months follow-up, the patelloplasty group had a significantly higher percentage of patients who had difficulty using stairs, a higher percentage of unsatisfied patients and a higher percentage of patients who rated their surgery as unsuccessful in returning them to normal daily activities. However, there was a selection bias because of the indications and thus the patelloplasty group had lower preoperative KSS to begin with. The authors concluded that patients undergoing patelloplasty may have more difficult revisions with other concomitant problems than isolated patellar bone loss and thus when a patellar component is unable to be implanted, a lower quality of result should be expected compared to when a patellar component is successfully retained or reimplanted.

Parvizi et al. [8] retrospectively compared the results of 19 isolated patellar component resection arthroplasties to 16 patellar component resection arthroplasties with concomitant revision of the tibial or the femoral component or both. At a mean follow-up of 7.9 years, patients in the latter group had significantly better KSS for pain and had undergone significantly less reoperations, although the number of patients was small. They recommended reimplantation of the patellar implant if the patellar thickness was more than 8–10 mm and emphasized that at the time of patelloplasty, correct positioning and stability of the tibial and femoral component should be carefully scrutinized, and considered for revision if malpositioned either axially or rotationally.

In a recent retrospective study, 49 patients who had a patellar component after revision TKA were compared to a matched cohort of 45 patients without a patellar component (including three patellec- tomyes) [57]. No difference was found between the two groups based on knees scores and patient satisfaction score and the authors suggested other variables may be more important than patella resurfacing and called for the need of further prospective randomized trials.

These studies suggest that for those patients with markedly compromised bone stock at the time of revision TKA, leaving the unresurfaced patellar bone remnant in place may be a reasonable option, although complication rates and persisting knee pain may be higher. Moreover, patelloplasty may be the only option in some cases.
6. Reconstruction/augmentation of the patellar bone stock

The amount of bone stock is the most important consideration while revising a patellar component. A minimum of 8–12 mm of residual patella is desirable to obtain adequate support for fixation [17,26,58]. Patellae with severe bone deficiency, precluding use of another patellar implant, occur in about 10% of revision TKA [59]. Although recent studies showing reconstruction with a small patellar remnant have been encouraging [60,61], further studies with a larger patient population and longer follow-up are required to assess the long-term benefits.

If the patella has too much cavitory bone loss to provide fixation for a traditional onlay patellar component, a biconvex inlay component may be used. Ikezawa and Gustilo [60] reported on implantation of a small biconvex patellar component in patellar shells as thin as 5 mm with an 8% radiolucent line formation with no fractures at two years follow-up. Similarly Maheshwari et al. [61] reported on the use of a biconvex component with as low as 4 mm (mean 6.5 mm) of remaining patellar bone in 20 revision TKA. At a mean follow-up of 34 months, there were no fractures or revisions. The average postoperative composite thickness was 14.5 mm. There was a significant increase in the mean postoperative KSS from 47 to 65 and from 45 to 89 for function and pain respectively with no patellar fractures or revision surgeries.

Cave and Rowe [62] had initially described a procedure where the degenerated surface of the patella is covered with a portion of the infrapatellar fat pad, which is elevated and sewn peripherally into the patellar rim to be interposed between the patella and the femoral trochlea. Later Buechel [63] described a patellar bone grafting procedure for TKA in twelve patients who had a prior patellectomy, where a 2.5 cm wide and a 1.0 cm thick structural bone graft was secured in a synovial pouch of patellar tendon in the location of the anatomic position of the previous patella. A similar technique had been proposed using the resected tibial plateau [64,65]. Tabutin [66] also described a procedure where the cancellous surface of an autologous monocortical iliac crest graft is apposed to the patellar bone and fixed with four 1.5 mm cortical screws. Any remaining defect is filled with morcellized cancellous bone. The new patellar component is then cemented to this composite. The prerequisites include an unfractured patella, sufficient quality and quantity of patellar bone to accept a graft and ensure fixation, and an intact extensor mechanism. Combining these principles, Hansen [59] reported on nine revision TKA (mean follow-up of 3 years) on whom bone grafting was done to restore severe patellar bone loss. The procedure involved creating a local synovially based tissue flap that was secured to the patellar rim to contain cancellous bone graft inserted into the patellar bone defect. The point of greatest patellar thickness measured intraoperatively 7–9 mm with a mean of 22 mm on the immediate postoperative radiographs and 19.7 mm at the time of final follow-up. There was a significant increase in the mean postoperative KSS from 39 to 91 and from 40 to 84 for function and pain, respectively. He suggested that this method imparts potential for restoring patellar bone stock (even for future resurfacing) and may improve functional outcome by facilitating patellar tracking and improved quadriceps leverage.

Vince et al. [67] have discussed the use of a ‘gull wing’ osteotomy to restore more normal convexity to a thin patellar remnant with the help of a longitudinal osteotomy which allows the patella to resume a V-shaped appearance, more suitable for patellar tracking. To date there have only been anecdotal cases with no substantial published results.

Naser and Poggie [68] reported on the use of a novel porous tantalum implant for augmentation or arthroplasty of the patella for 11 patients undergoing a revision TKA (including prior patellectomies, patellar fractures, prosthesis failures and severe bone loss). There was a significant increase in the mean postoperative KSS from 24 to 69, from 20 to 53, and from 62° to 103° for function, pain, and range of motion, respectively. In another study Nelson et al. [69] reported excellent or good results in 17 of 20 patients who underwent revision TKA with implantation of a trabecular metal patellar shell at a mean of 23 months follow-up. Three patients sustained postoperative polar patella fractures but the trabecular metal component was found to be stable in two patients requiring resurgery.

7. Excision the patellar component (patellectomy)

Although there are no substantial studies to report the results of partial patellectomy during revision TKA, the results of TKA after previous patellectomy have been less satisfactory [13,27,70–74]. Many authors consider patellectomy to be a relative contraindication for a cruciate retaining design [70–72,75,76]. Patellectomy is associated with markedly inferior functional results, difficulties with weakness and delayed disruption of the extensor mechanism perhaps attributable to abnormal knee biomechanics, diminished quadriceps torque and strength, and ligament instability [8,16,74,76,77]. Thus patellectomy is not routinely recommended and should be the last resort in the surgeons’ armamentarium as this procedure is fraught with a higher complication rate and lower functional score.

Recently, Busfield and Ries [78] reported on the use of patellar allograft for six primary and three revision TKA after previous patellectomies. The patients’ extensor mechanism soft tissue sleeve was intact, but the patella was not present. Deficient patellae were reconstructed using patellar ligament (whole patella) quadriceps tendon allograft. The allograft improved quadriceps function by one grade and the KSS for knee (from 59 to 85) and function (from 63 to 67), but was associated with a high complication rate. The authors did not recommend routine use of this procedure.

The idea of using a trabecular metal patellar implant to provide patellar fulcrum and improve quadriceps function in patients with previous patellectomy is again novel. Although two reported series on trabecular metal patellar implant [68,69] had some patients with previous patellectomies, the authors did not comment or compare the results of these specific cases. However, it seems that the stable fixation of a trabecular metal patellar component can be achieved when residual bone is present for implant fixation, but early loosening is likely to occur when soft tissue is used for fixation to the implant. Ries et al. [79] reported on 16 patients (18 TKA) with severe patellar bone loss using trabecular metal patellar reconstruction. All six patients (seven TKA) with no initial patellar bone stock had loosening and migration of the patellar component within 1 year. Two of these developed necrosis of the extensor mechanism leading to extensor mechanism discontinuity. In contrast, there was only one septic loosening out of 10 patients (11 TKA) in whom initially at least 50% of the patellar component surface was covered by host bone. Similarly in another recent report by Kwong and Desai [80], seven patients with previous patellectomies were reconstructed with tantalum-based augmentation patellar components. No patient had a favorable outcome: the implants loosened within 15 months in three patients, two patients remained symptomatic despite fixation, one patient developed wound complications due to bulk of the implant and the procedure was abandoned in one patient due to failure of wound closure.

8. Patellar fractures

Periprosthetic patellar fractures have been recently summarized by Sheth et al. [81]. Fracture of the patella after TKA is an infrequent complication, with a reported prevalence of 0.05% in unresurfaced patella and 0.2–21% in resurfaced patella [9,81–87]. Periprosthetic patellar fractures are more likely to occur postoperatively than intraoperatively, and they are more frequent after revision surgeries. Berry [82] reported a postoperative patellar fracture rate after revision surgery of 1.8% which was more than
double the rate after a primary total knee arthroplasty (0.7%). This was nine times higher than the intraoperative fracture rate (0.2%) during revision surgery. Fracture may be due to trauma, fatigue or stress [81,87,88]. Various atraumatic risk factors may be linked to the patient, implant or technique [58,81,89]. Fatigue fractures are more common and may be due to avascularity, malalignment of the components, excessive or asymmetrical resection, or the use of a large central peg fixation [3,9,36,75,81,85,90–93].

Most of these fractures are incidental findings and more than 80% of the patients with a periprosthetic fractures reported by Tria et al. [86] and Issall et al. [94] were asymptomatic and were diagnosed on the basis of routine radiographs. Findings in symptomatic patients include anterior knee pain with patellar tenderness along with effusion, extensor weakness, instability or difficulty with stairs [95]. Treatment options for patellar fractures after a TKA range from non-operative methods to open reduction and internal fixation, component resection and patelloplasty, use of novel trabecular metal implants, partial or complete patellectomy, revision of the isolated patellar component or of all the three components, and even reconstruction of the extensor mechanism using an allograft [81]. Decision making concerning the optimal treatment can be complex, and treatment may be difficult [58,89]. When surgery is needed, the surgeon must be prepared to deal with extensor mechanism disruption, a failed or loose patellar component, and poor remaining bone stock.

The pattern of fracture can affect the result [3,81,83,85,87]. Although, there is no universally accepted validated classification system that can provide functional outcome measures or be used as an adjunct to a clinical treatment algorithm, Ortizguez and Berry [85] have recently developed a useful system based on the stability of implant, integrity of the extensor mechanism and the remaining bone stock. Type I fractures (stable implant with intact extensor mechanism) are treated non-operatively. Type II fractures (disrupted extensor mechanism) require extensor mechanism repair with partial or complete patellectomy or open reduction and internal fixation. Type III fractures (loose implants with intact extensor mechanism) are subdivided into Type IIIa (good remaining bone stock) and Type IIIb (poor remaining bone stock). If the patient is sufficiently symptomatic, operative intervention should be considered, with patellectomy being an option. Type IIIa fractures may be treated with component revision or component resection, and Type IIIb fractures can be treated with component removal with patelloplasty or patellectomy. Operative treatment was associated with a higher rate of complications and reoperations. There was a 50% complication rate and 42% reoperation rate for a type II fractures. Similarly of all type III fractures, 57% continued to be symptomatic and nearly 1/3 had complications related to the fracture management.

Thus suboptimal results with high complication rates have typically been reported in the literature, and little improvement in functional outcomes has been demonstrated even with newer techniques. Newer strategies, such as use of trabecular metal implants [68,69] that allow simultaneous fixation of the fracture and resurfacing with the use of bone graft in conjunction with bone morphogenic proteins, may be helpful in the future to manage these complex situations [81].

9. Conclusion

Patellar issues need to be carefully addressed during any revision TKA. The various options for patellar component revision include retention, replacement, patelloplasty, patellectomy and other augmentation procedures. The choice of treatment is often made by balancing what is technically feasible with the risk of potential complications and takes into account the reason for the revision, the type of implant (i.e., metal-backing or all-polyethylene), the duration of implantation, the fixation, the stability, the sterilization technique, the wear, the presence of osteolysis, the compatibility with the femoral component, and most importantly the remaining bone stock. Isolated patellar revision is associated with high complication rates and recurrent failure when poor patellar tracking, incongruent designs and malalignment of the femoral and tibial components exist. Retention of a well-fixed all-PE (non-oxidized) patella is advocated where possible and revision of metal-backed patella is recommended (unless well fixed with poor bone stock). In the situation of a deficient patella, patelloplasty, augmentation procedures and very rarely patellectomy are other viable options.

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