Management of the Deficient Patella in Revision Total Knee Arthroplasty

Ryan M. Garcia MD, Matthew J. Kraay MS, MD,
Patricia A. Conroy-Smith RN, Victor M. Goldberg MD

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Abstract There are a number of options available to manage the patella when revising a failed total knee arthroplasty. If the previous patellar component is well-fixed, undamaged, not worn, and compatible with the femoral revision component, then it can be retained. When a patellar component necessitates revision and is removed with adequate remaining patellar bone stock, an onlay-type all-polyethylene cemented implant can be used. Management of the patella with severe bony deficiency remains controversial. Treatment options for the severely deficient patella include the use of a cemented all-polyethylene biconvex patellar prosthesis, patellar bone grafting and augmentation, patellar resection arthroplasty (patelloplasty), performing a gull-wing osteotomy, patellectomy, or the use of newer technology such as a tantalum (trabecular metal) patellar prosthesis. Severe patellar bone deficiency is a challenging situation because restoration of the extensor mechanism, proper patellar tracking, and satisfactory anatomic relationships with the femoral and tibial components are critical for an optimal clinical outcome.

Level of Evidence: Level IV, therapeutic study. See the Guidelines for Authors for a complete description of levels of evidence.

Introduction

Patellar resurfacing in TKA has become more routine despite controversy about whether it results in improved patient outcomes [10, 12, 13, 15, 42]. With the number of primary TKA procedures expected to increase by more than sixfold in the next 25 years and the number of revision procedures expected to double within the next 8 years [26], management of the failed patellar component at the time of revision TKA becomes an essential aspect of the revision procedure.

The goal of restoring the patellar component is to obtain stable fixation of a new implant, provide painless articulation of the extensor mechanism with the femur, and to optimize the extensor mechanism function while minimizing complications. When evaluating the patella during revision TKA, a decision must be made to retain the existing patellar component or to revise it. Once the decision has been made to revise the patellar component, the condition of the existing patella and extent of patellar bone deficiency after implant removal often determine which treatment options are most applicable. Although a variety of potential treatment options exist for the deficient patella, selecting the optimal procedure can be challenging.

Using a structured review of the literature, we identified currently established treatment options, which include using an onlay-type cemented prosthesis, performing a patellar bone grafting and augmenting procedure, performing patellar resection arthroplasty (patelloplasty),

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R. M. Garcia (✉), M. J. Kraay, P. A. Conroy-Smith,
V. M. Goldberg
Department of Orthopaedic Surgery, University Hospitals Case
Medical Center, Case Western Reserve University, 11100 Euclid
Avenue, Cleveland, OH 44106, USA
e-mail: ryangarcia78@gmail.com

performing gull-wing osteotomy, or completely removing the existing patella (patellectomy) [2–4, 8, 11, 19, 21, 27, 29, 34, 35, 38, 40]. Newer technology and recently published reports have introduced the use of a cemented all-polyethylene biconvex patellar prosthesis and the tantalum (trabecular metal) patellar prosthesis for the treatment of the deficient patella during revision TKA [23, 30, 32, 33, 37].

Search Strategy and Criteria

We identified relevant articles published in the English literature that met predetermined inclusion criteria. Our

inclusion criteria included (1) published reports on revision TKA that specifically addressed patellar treatment options and outcomes; and (2) all potential levels of evidence (with specific attention toward Level I evidence). Our exclusion criteria included (1) non-English published reports; (2) any unpublished reports or data that were not peer-reviewed; and (3) published reports on the global outcomes of revision TKA that do not specifically address treatments of the patella.

We performed an Ovid search of the Medline database from January 1950 to December 2007 identifying the population (knee, arthroplasty, replacement), the intervention (revision, reoperation), and the methodology (clinical trial, retrospective review). The following search terms

Table 1. Literature comparison

Author	Title	Year of publication	Journal	Level of evidence
Hanssen [19]	Bone-grafting for severe patellar bone loss during revision knee arthroplasty	2001	J Bone Joint Surg Am	IV
Barrack et al. [2]	Revision knee arthroplasty with patella replacement versus bony shell	1998	Clin Orthop Relat Res	III
Parvizi et al. [35]	Patellar component resection arthroplasty for the severely compromised patella	2002	Clin Orthop Relat Res	IV
Pagnano et al. [34]	Patellar component resection in revision and reimplantation total knee arthroplasty	1998	Clin Orthop Relat Res	IV
Barrack et al. [4]	Patellar options in revision total knee arthroplasty	2001	Orthopedics	III
Barrack et al. [3]	The results of retaining a well-fixed patellar component in revision total knee arthroplasty	2000	J Arthroplasty	III
Lonner et al. [29]	Fate of the unrevised all-polyethylene patellar component in revision total knee arthroplasty	2003	J Bone Joint Surg Am	IV
Nasser and Poggie [32]	Revision and salvage patellar arthroplasty using a porous tantalum implant	2004	J Arthroplasty	IV
Nelson et al. [33]	Use of a trabecular metal patella for marked patella bone loss during revision total knee arthroplasty	2003	J Arthroplasty	IV
Ries et al. [37]	Porous tantalum patellar augmentation: the importance of residual bone stock	2006	Clin Orthop Relat Res	IV
Ikezawa and Gustilo [23]	Clinical outcome of revision of the patellar component in total knee arthroplasty: A 2 to 7 year follow-up study	1999	J Orthop Sci	IV
Maheshwer et al. [30]	Revision of the patella with deficient bone using a biconvex component	2005	Clin Orthop Relat Res	IV
Masri et al. [31]	Effect of retaining a patellar prosthesis on pain, functional, and satisfaction outcomes after revision total knee arthroplasty	2006	J Arthroplasty	III
<i>Previous review articles</i>				
Rorabeck et al. [38]	Patellar options in revision total knee arthroplasty	2003	Clin Orthop Relat Res	
Hanssen and Pagnano [21]	Revision of failed patellar components	2004	Inst Course Lect	
Laskin [27]	Management of the patella during revision total knee replacement arthroplasty	1998	Orthop Clin North Am	
Rosenberg et al. [40]	The patella in revision total knee arthroplasty	2003	J Bone Joint Surg Am	
Rand [36]	Treatment of the patella at reimplantation for septic total knee arthroplasty	2003	Clin Orthop Relat Res	
Hanssen [20]	Patellar revision: bringing back the bone	2003	Orthopedics	
Chalidis et al. [16]	Management of periprosthetic patellar fractures: a systematic review of literature	2007	Injury	

were used in continuous combinations: (1) knee; (2) arthroplasty; (3) replacement; (4) revision; and (5) reoperation. Additional search terms were then added to narrow the population of published reports. We used the following search terms to isolate published reports relating to specific treatments of the patella: (1) patella; (2) patellar; (3) patelloplasty; (4) patellectomy; (5) biconvex; (6) tantalum; (7) trabecular; and (8) gull-wing. Boolean operators “and” and “or” were used. We used these clinical search queries and keyword searches with additional search engines, namely, PubMed, Cochrane Controlled Trials, and Cochrane Systematic Reviews. Three of the authors (RMG, MJK, VMG) reviewed the lists of potential reports derived from each of the search engines. The title of each report and its associated abstract were each reviewed for inclusion and exclusion eligibility. Any previous review articles on this topic were independently noted. Additionally, a manual search of the bibliography of each eligible report and prior review article was performed to identify any further studies that might meet inclusion criteria.

Our initial Ovid search of the Medline database identified 135 potential articles. Our Pubmed search of the Medline database identified 98 potential articles while our review of Cochrane Controlled Trials and Cochrane Systematic Reviews each identified 8 potential articles. Of these, 14 met our inclusion criteria and seven additional review articles were noted (Table 1).

Management of the Patella in Revision TKA

Retaining the Existing Patellar Component

One surgical option is to retain the patellar component during revision TKA. This is regarded as the simplest option and is probably the most commonly used. Retaining the patellar component is associated with the lowest morbidity because it avoids bone loss associated with implant removal. When considering patellar component retention, a complete evaluation of the patellar prosthesis should meet the following criteria: it must be well-fixed without radiographic or clinical signs of loosening or instability, there should be no or minimal signs of damage or wear, and it should be in appropriate alignment and positioning to properly track within the femoral intercondylar groove. The extent and degree of damage that is acceptable when retaining the patellar component remains controversial with further investigation necessary [29]. Optimally, the retained patellar component should articulate with the femoral component of the same manufacturer and design. When it is unreasonable to specifically match component designs, the surgeon must evaluate the compatibility of the retained patellar component and weigh it against the

morbidity associated with patellar component revision [29].

Although a well-fixed and stable metal-backed patellar component can be retained, we recommend revising all metal-backed patellar components to a cemented all-polyethylene patellar component because of the high incidence of catastrophic failures associated with metal-backed implants of many designs [1, 5, 7, 25, 28, 39]. Rorabeck et al. [38] similarly suggested surgeons should consider the revision of all metal-backed patellar components regardless of patellar component fixation, damage, or positioning. Some authors, such as Barrack et al. [3], suggest it is reasonable to retain a well-fixed and stable metal-backed patellar component, particularly when the remaining patellar bone stock is poor. Others may argue that retaining a metal-backed patellar component of a mobile-bearing design is also a reasonable option because long-term successful outcomes have been reported [22, 24]. Clear data to decide the optimal management of a well-fixed metal-backed patellar component during revision TKA have not been reported.

Barrack et al. [3], in a retrospective study, compared the outcome of retaining a well-fixed, undamaged, and properly tracking patellar component with the outcome of revising the patellar component at the time of revision TKA. These authors noted 12 of the 34 retained patellar components were metal-backed, but the decision to retain these particular components was made only secondary to the poor remaining bone stock associated with the patellar remnant. Overall, they reported no difference between study groups with regard to Knee Society knee scores and no differences in patient satisfaction, pain relief, or return to desired activities [3]. The results of this study favor the retention of a patellar component that is well-fixed, not damaged, and tracking centrally in its femoral articular surface.

In an additional retrospective study, Lonner et al. [29] assessed the outcomes of 202 TKA revisions in which an all-polyethylene patellar component was retained. Similar to the results of Barrack et al. [3], this report recommended the retention of a well-fixed, undamaged, and all-polyethylene patellar component. Retaining the patellar component was associated with a low failure rate and a major improvement in patient Knee Society knee scores and knee function scores. The authors concluded, however, the likelihood of failure of a retained all-polyethylene component was increased if the polyethylene was originally gamma-irradiated in air as opposed to an inert environment. They recommended investigation of the manufacturer's sterilization process before the revision procedure and revision of patellar components that were initially sterilized with gamma irradiation in air.

Masri et al. [31] also demonstrated improvements in pain, function, and patient satisfaction in a series of knees

undergoing revision TKA in which the patella component was retained, revised, left unrevised, or left unresurfaced. In this comparative study, knee outcomes were comparable regardless of whether a patellar component was present (retained patellar components or revised patellar components) or absent (patellar components removed and not revised or unresurfaced patella). Although these authors did not specifically address the outcome of retaining the patellar component, they concluded all patellar components that were well-fixed, stable, and unworn should be retained.

Patellar Component Revision Options

If the patellar component is malpositioned, damaged, worn, mechanically loose, or does not track appropriately within the intercondylar groove of the femur, it should be revised. Revision TKA for subacute or chronic sepsis may also require removal of the patellar component and second-staged reimplantation [36]. The principles of patellar management and revision are the same for both mechanical failure and sepsis. Management of a bone-deficient patella can be complex because surgical and prosthetic options can be limited. Although the condition of the patellar remnant and extent of patellar bone deficiency may suggest which revision procedure and patellar component is most appropriate, studies to clearly delineate the correct treatment choice have not been established and remain controversial.

Sources of severe bone loss include excessive bone removal with the prior patellar component, osteolysis, or excessive patellar resection during the primary TKA. The importance of the patella in contributing to knee kinematics has been well established [40]; therefore, authors have recommended the complete abandonment of patellectomy in revision TKA and recommended either a patellar bone augmentation procedure in an attempt to restore the poor patella bone stock or a patellar resection arthroplasty (patelloplasty) procedure [4, 19, 21]. In more recent reports, severe bone-deficient patellae with less than 10 to 12 mm of cortical bone have been managed successfully using either an inlay-type cemented, all-polyethylene, dome-shaped biconvex component or a porous trabecular metal (tantalum) component [23, 30, 32].

Onlay-type Patellar Prosthesis

If the prior patella component can be removed with minimal bone loss, then a standard onlay-type patellar component that matches the design of the femoral component can be used. The patellar bone thickness that is required to accommodate a cemented all-polyethylene,

onlay-type patellar prosthesis has not been clearly studied or validated in the literature. A patellar remnant of 10 to 12 mm thickness that is uniform throughout the patella has been described as adequate patellar bone stock to accommodate a cemented best-fit all-polyethylene, onlay-type patellar prosthesis [36]. Although it is optimal to revise the patellar component with the same manufacturer and design of the femoral component, previous authors have reported success with components that are at least “compatible” [29].

Exposure of the patella during the revision TKA can often be difficult and may require the use of an extensile approach to the knee. Rorabeck et al. [38] has commented on many of the potential difficulties that can be encountered when attempting to expose the patella and has recommended the use of a quadriceps snip or a tibial tubercle osteotomy in addition to minimizing the lateral retinacular release required to evert the patella. After exposing the periphery of the patella and examining the bone and implant interface, the implanted patellar component can then be removed with an oscillating saw or an osteotome. Removal of a metal-backed patellar component can be more difficult and often requires the use of a diamond-edged circular saw blade to resect the fixed pegs [17]. Meticulous removal of any remaining cement or fibrous tissue is also essential for the revised cemented patellar implant. The patella is then prepared in a standard fashion to accept a new cemented onlay, all-polyethylene patellar component. At the conclusion of the revision procedure, it is vital to assess patellar tracking and positioning to optimize functional outcomes.

All-polyethylene Biconvex Patellar Prosthesis

In the revision situations of moderate to severe central patellar bone stock deficiency with an intact peripheral cortical rim, use of an all-polyethylene, biconvex, dome-shaped patellar component (Genesis Biconvex patella; Smith and Nephew, Inc, Memphis, TN) can be considered. The biconvex patellar component was designed for cemented implantation as an inset-type patellar prosthesis. A patella remnant composed of a 5- to 10-mm thick bony shell can typically accommodate the biconvex patellar prosthesis. Maheshwer et al. [30] reported on 20 patellar revisions in which the Genesis Biconvex patella (Smith and Nephew, Inc) was implanted into a patellar remnant with an average minimal thickness of 6.5 mm (range, 4.5–10 mm). At a minimum followup of 24 months (average, 34 months; range, 24–65 months), these authors reported improved Knee Society knee scores and satisfactory knee range of motion (average, 105°) without any patellar fractures or other complications requiring additional

surgery [30]. Although three patients reported mild anterior knee pain with flexion and difficulty performing stair-climbing, these symptoms were not sufficient enough to warrant a subsequent revision procedure [30].

Similarly, Ikezawa and Gustilo [23] also reported successful outcomes in 23 patellar-deficient knees that underwent revision TKA with the Genesis Biconvex patella (Smith and Nephew, Inc) at a mean followup of 46 months. The average patellar thickness after removal of the prior patellar component was 7.9 mm, which was further reduced to an average thickness of 5 mm after preparing the patella for cemented implantation of the biconvex component. The average Knee Society knee score and knee function score improved after the revision procedure with an average range of motion of 92°. There were no patellar fractures in this series of very thin patellar remnants; however, three complications were reported. These three complications necessitated a second revision procedure, including two lateral retinacular releases performed for patellar subluxation and one knee fusion performed as a salvage procedure after a chronic knee infection.

Porous Tantalum (trabecular metal) Patellar Prosthesis

Recently, the porous tantalum patellar component has been introduced into practice to address the severely bone-deficient patella that cannot adequately accommodate an onlay or inlay cemented patellar prosthesis. The design rationale for this particular component relies on tissue and bone ingrowth into the porous tantalum prosthesis. Rather than cementing this implant to the patellar remnant, it is circumferentially sutured to any bone or soft tissue that is present on the patellar remnant [33]. The porous tantalum augmentation then serves as the foundation for cementing a conventional-type patellar component. The thickness of the tantalum component is then added to the thickness of the cemented polyethylene button to avoid overstuffing the patellofemoral joint. One distinct advantage of the tantalum patellar implant over the biconvex polyethylene component is the porous tantalum prosthesis does not necessarily require a cortical rim of patellar bone to support the implanted prosthesis.

Although traditional porous patellar components have demonstrated insufficient bone and soft tissue ingrowth capabilities, the porous tantalum component has exceptional capacity for bone and soft tissue ingrowth [9, 18]. Although tantalum has the capability of soft tissue ingrowth, Ries et al. [37] point out the presence of even a minimal extent of patellar bone may be necessary to achieve a successful result. In this series, patellae covering 50% or more of the tantalum surface had considerably

lower loosening rates when compared with patellae that were implanted with absent bone stock.

In a recent study by Nasser and Poggie [32], the porous tantalum patellar component (Trabecular Metal; Zimmer Trabecular Metal Technologies, Zimmer, Allendale, NJ) was used in 11 patellar revisions with such severe patellar deficiency that other patellar prosthesis options were not possible. Nasser and Poggie [32] reported at a mean of 32 months followup that patients treated with the porous tantalum patellar component had considerably improved pain and function scores. Additionally, all but one patient (who had a recurrent episode of patellar trauma resulting in a patellar fracture) had radiographic evidence of osteointegration [32].

Nelson et al. [33] reported the results of 20 consecutive patients treated with the porous tantalum patellar component (Zimmer) at a mean of 23 months followup. The tantalum patellar component was used when the patellar bone loss was so severe that it precluded the use of a standard cemented patellar prosthesis (19 patients) or a prior patellectomy had been performed (one patient). Good to excellent results were noted in 17 of the 20 patellar revisions and overall Knee Society knee scores and knee function scores considerably improved at followup. Three patellar fractures occurred after implantation of the tantalum patellar prosthesis. Although short-term results after the use of the tantalum patellar prosthesis appear promising, long-term outcomes are required to define the role of this technology in patellar revisions.

Patellar Resection Arthroplasty (patelloplasty)

Performing a patellar resection arthroplasty (patelloplasty) procedure may be viewed more as a historical treatment option, particularly because newer prostheses and surgical techniques have been introduced to accommodate severe patellar deficiency [2, 4, 34, 35]. Previous authors described a patellar resection arthroplasty as removal of the prior patellar prosthesis and any additional osteophytes followed by patellar contouring to allow articulation with the femoral component. The decision to perform a patellar resection arthroplasty is typically based on an absence of sufficient patellar bone stock (less than 10 mm thick) to allow for stable fixation of a new patellar prosthesis [2, 34, 35]. Masri et al. [31] reported having a patellar component (patellar retention or revision) after revision TKA may not considerably change the clinical outcome when compared with knees when the patellar component was absent (patellar resection arthroplasty or unresurfacing). In contrast to these findings, others have clearly demonstrated the results and clinical outcomes of patellar resection

arthroplasty are inferior to patellar component revision and patients should be informed of these potential limitations.

Pagnano et al. [34] reported on a series of 34 knees that underwent patellar resection arthroplasty in a series of patellae with poor bone stock (typically 10 mm or less). An overall improvement in Knee Society knee scores and function scores was noted; however, 10 patients (29%) reported persistent patellofemoral symptoms with seven patients reporting moderate or severe pain. Five knee complications (15%) were reported in this series but without a subsequent revision procedure performed.

In a series of 113 revision TKA procedures by Barrack et al. [2], 21 knees underwent patellar resection arthroplasty when the remaining patellar bone stock was so insufficient (typically 12 mm or less) that a patellar prosthesis could not be reimplanted. When the outcomes of these knees were compared with knees that underwent patellar component retention or successful revision (92 cases), a considerably lower return to normal activities was demonstrated (79% versus 98%). Additionally, patients who underwent patellar resection arthroplasty also reported more patellofemoral symptoms and difficulty managing stairs, squatting, and kneeling.

Parvizi et al. [35] reported the outcome of patellar resection arthroplasty was encouraging in the short-term but declined with further followup. Knee Society knee scores and knee function scores improved at 2 years postoperatively in these patients with only six patients (17%) having persistent knee symptoms. However, with longer followup, knee scores subsequently declined with 18 patients eventually (51%) reportedly having persistent knee symptoms. Radiographic analysis also demonstrated six knees with a patellar fracture and one knee with a patellar dislocation. Ultimately, six knees underwent patellectomy.

Satisfactory pain scores and physical function can be achieved after a patellar resection arthroplasty procedure. Although superior outcomes typically follow revision of the patellar component, patellar resection arthroplasty should still remain a viable surgical option in severely compromised situations [2, 4, 34, 35].

Bone Grafting and Patellar Bone-augmenting Procedures

Although it is possible to implant a tantalum patellar component (Zimmer) in situations with minimal to no patellar bone stock, Ries et al. [37] have cautioned that 50% of the prosthesis should be in contact with native patellar bone. In cases of prior patellectomy or severe bone deficiency, authors have reported novel techniques to try to restore patellar bone stock [11, 14, 19].

Buechel [11] described a unique technique to augment the quadriceps and patellar tendon junction in patellectomized patients undergoing TKA. After a subsynovial pouch is created underneath the patellar tendon, autograft or allograft bone is implanted and sutured in situ. Seven knees (six patients) underwent this patellar-augmenting procedure and all but one knee demonstrated good to excellent results with adequate extension power to allow proper gait without the need for a walking aid.

Hanssen [19], in a more recent report, described the technique of bone grafting a severely compromised patellar remnant and covering this bone augmentation with the fibrous pseudomeniscus that encompasses the patella. A soft tissue flap is elevated and constructed from the peripatellar fibrous scar tissue, the fascia lata, or tissue from the suprapatellar pouch and sutured circumferentially around the patella to help retain the bone graft. Hanssen reported nine knees (eight patients) treated with this technique demonstrated improved Knee Society knee scores and an increased patellar thickness from 7 mm to 9 mm intraoperatively to an average radiographic thickness of 19.4 mm at followup. Only one subsequent reoperation was necessary in this series for reasons unrelated to the patella [19].

Gull-wing Patellar Osteotomy

Specific reports on the outcomes of a “gull-wing” osteotomy of the patella could not be located in our Ovid search of the Medline database. Vince et al. [41] have described using a sagittal osteotomy of the patella as a salvage technique in the management of severe patellar bone deficiency. Once the osteotomy is completed, the remaining patellar bone is allowed to hinge open to cover a portion of the medial and lateral femoral condyle. The gull-wing osteotomy avoids patellectomy and leaves a portion of the extensor mechanism intact.

Patellectomy

We identified no report that specifically documents the outcomes of revision TKA when patellectomy was performed for severe patellar deficiency. In contrast, prior studies have documented the outcomes of TKA in patients with previous patellectomy are often poor, which has led to the development of novel procedures to restore and augment the absent patella [6, 11]. Patellectomy should be avoided during revision TKA; rather, the deficient patella should be restored with bone augmentation in an attempt to optimize functional outcomes.

Discussion

Management of the patella during revision TKA can be challenging, particularly when the bone stock of the remaining patella is severely compromised. Despite this, a variety of treatment options exist with successful outcomes previously reported. Newer technology and recently published reports have introduced the tantalum and the biconvex patellar prostheses with reasonable success for these complex situations. Our review has examined currently available literature from which an algorithm of treatment options can be followed.

We recognize a few of the limitations associated with this review. This is an observational study of a series of previously reported nonrandomized trial data. The lack of Level I and Level II evidence limits the various treatment options that can be definitively recommended.

Based on currently available literature, we believe the following algorithm is appropriate to manage the patellae in revision TKA. First, if the previous patellar component is well-fixed with only minimal damage, reasonably compatible with the femoral component, and tracks properly within the femoral groove, it can be retained. When the patellar component must be revised and adequate patellar bone stock exists, then an onlay-type patellar prosthesis can be used. In situations of severe patellar deficiency that precludes the use of an onlay patellar prosthesis but a stable cortical rim and minimal central bone thickness of 5 to 8 mm is present, then a cemented all-polyethylene, biconvex prosthesis should be considered. If the patellar remnant is without a cortical rim of support and has less than 5 mm of central thickness, then the tantalum patellar prosthesis (Zimmer) can be considered. In situations of extreme patellar deficiency or prior patellectomy, an attempt can be made to bone graft and augment the patellae. Although patellar resection arthroplasty can lead to inferior patient outcomes, even the smallest patellar remnant can still contribute to extensor mechanism functioning. Patellectomy should be avoided.

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