



Original research

A classification-based approach to the patella in revision total knee arthroplasty

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ABSTRACT

Background: There is a paucity of data to guide management of the patella in revision total knee arthroplasty (RTKA). The purpose of this study was to review our experience with patellar management in RTKA.

Methods: We retrospectively reviewed 422 consecutive RTKAs at a minimum of 2 years (mean, 42 months). Patellar management was guided by a classification that considered stability, size, and position of the implanted patellar component, thickness/quality of remaining bone stock, and extensor mechanism competence.

Results: Management in 304 aseptic revisions included retention of a well-fixed component in 212 (69.7%) and revision using an all-polyethylene component in 46 (15.1%). Patella-related complications included 5 extensor mechanism ruptures (1.6%), 3 cases of patellar maltracking (1.0%), and 2 periprosthetic patellar fractures (0.7%). Of 118 2-stage revisions for infection, an all-polyethylene component was used in 88 (74.6%), patelloplasty in 20 (16.9%), and patellectomy in 7 (5.9%). Patella-related complications included 4 cases of patellar maltracking (3.4%), 3 extensor mechanism ruptures (2.5%), and 1 periprosthetic patellar fracture (0.8%).

Conclusions: Septic revisions required concomitant lateral releases more frequently (38.1% vs 10.9%; $P < .02$) but had a similar rate of patellar complications (6.8% vs 3.3%; $P = .40$). No cases required rerevision specifically for failure of the patellar component. Patients who had a patelloplasty had worse post-operative Knee Society functional scores than those with a retained or revised patellar component. In most aseptic RTKAs, a well-fixed patellar component can be retained. If revision is required, a standard polyethylene component is sufficient in most septic and aseptic revisions. Rerevisions related to the patellar component are infrequent.

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Introduction

Managing the patellar component in revision total knee arthroplasty (RTKA) is challenging, given the small size and thickness of the patella, which limits reconstructive options [1–5].

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A fracture or other failure of the patellar component can lead to disruption of the extensor mechanism, which is among the most serious complications of TKA with the potential for long-lasting disability and the need for salvage procedures, such as an extensor mechanism allograft or knee arthrodesis. Management of the patella is further complicated by the array of reconstructive options available to the surgeon, which include the following: (1) retention of a well-fixed component; (2) revision using a standard or biconvex all-polyethylene component; (3) revision using a porous metal component [6–8]; (4) impaction bone grafting [9]; (5) gull-wing osteotomy [10,11]; (6) patelloplasty (shaping the patellar remnant but leaving it unresurfaced); and (7) patellectomy.

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Despite the growing number of RTKAs, there is sparse literature to guide selection among treatment options for management of the patella. The senior authors of this article apply a classification-based approach to the patella in the revision setting. Through review of a large series of RTKAs, we sought to describe how the patella was managed and to examine associated outcomes using this systematic approach. Specifically, we assessed the following: (1) For aseptic RTKAs and 2-stage RTKAs for infection, how frequently did the patellar component need to be revised, which techniques were required, and what was the rate of patella-related complications postoperatively? (2) What were clinical outcome scores at a minimum of 2 years? (3) How did demographics, management, and outcomes differ between aseptic and septic RTKAs?

Material and methods

Following institutional review board approval, we retrospectively reviewed the records of 557 consecutive patients who underwent RTKAs by the 2 senior authors between November 2002 and May 2010. Exclusion criteria included patients who had undergone a previous patellectomy (6) or extensor mechanism allograft (16) (given the absence of a patella), and those who underwent an isolated bearing surface exchange (52), revision of a partial knee arthroplasty to a TKA (39), arthrodesis (4), or amputation (1) at the index revision (given the general lack of a treatment dilemma regarding the patella in these scenarios). This left 439 RTKAs in 439 patients eligible for inclusion. Of these, 17 (3.9%) were lost to follow-up before 2 years, leaving 422 patients with 422 RTKAs. These 161 males (38.2%) and 261 females (61.8%) had a mean age at the time of surgery of 65.6 years (range, 35–92 years). These patients were evaluated at a mean of 42 months (range, 24–144 months).

The most common reasons for revision were aseptic component loosening in 155 cases (36.7%), deep infection [12] in 118 (27.9%), and instability in 52 (12.3%; Table 1). All 118 infected cases were treated with a 2-stage exchange protocol with interval antibiotic spacer placement. The 304 aseptic revisions included 280 revisions of the tibial and femoral components (92.1%), 15 isolated tibial revisions (4.9%), 6 isolated femoral revisions (2.0%), and 3 isolated patellar component revisions (1.0%). The mean time from primary arthroplasty to index revision was 76.2 months (range, 2–330 months). Mean American Society of Anesthesiologists Physical Status Classification score was 2.5 (range, 1–4) for aseptic cases and 2.6 (range, 1–4) for 2-stage revisions. Among aseptic revisions, initial diagnoses for primary TKA included osteoarthritis in 269 patients (88.4%), rheumatoid arthritis in 20 patients (6.6%), and post-traumatic arthritis in 15 patients (4.9%). Among infected revisions, initial diagnoses included osteoarthritis in 101 patients (85.6%), inflammatory arthritis in 15 patients (12.7%), and post-traumatic arthritis in 2 patients (1.7%).

In all revisions, the patella was managed using a classification that considered the stability, size, and position of the implanted

Table 1
Indications for revision surgery.

Indication	Number (n = 422), n (%)
Aseptic loosening	155 (36.7)
Periprosthetic joint infection	118 (27.9)
Instability	52 (12.3)
Stiffness	43 (10.2)
Extensor mechanism complication	24 (5.7)
Polyethylene wear	17 (4.0)
Periprosthetic fracture	7 (1.7)
Component malrotation	6 (1.4)

Table 2
Classification of the patella in revision total knee arthroplasty.

Type	Description	Management
1	Component well fixed, appropriately sized and positioned	Retention
2	Component loose or requires revision for malpositioning/sizing or deep infection	Revision
2A	>10 mm patellar remnant and adequate cancellous bone to achieve stability with standard 3-peg component	Standard, cemented 3-peg component
2B	<10 mm patellar remnant and/or deficient cancellous bone precluding the use of a standard 3-peg component	Specialized technique to reconstruct; impaction grafting, porous metal patella, or patellar osteotomy
3	Fragmentation of the patella that precludes reconstruction	Tubularization/centralization of the extensor mechanism
4	Incompetent extensor mechanism	Reconstruction of the extensor mechanism

patellar component; thickness and quality of the remaining host bone stock; and competence of the extensor mechanism (Table 2).

Each patient was evaluated preoperatively and postoperatively at 3 weeks, 6 weeks, 3 months, and annually thereafter for examination and radiographic follow-up. At each visit, standard evaluation measures included Knee Society Score (KSS) for knee and function [13] and plain radiographs (anteroposterior, merchant, and lateral views of the affected knee). Radiographs were independently reviewed preoperatively and postoperatively by 3 clinicians to determine if the patellar component was loose; the patellar component was considered loose if at least 2 of 3 agreed there was evidence of migration on serial radiographs.

For all patients, KSS preoperatively and at final follow-up were compared using paired *t* tests. Demographics, patellar management, and clinical outcome scores were compared between aseptic and septic revisions using *t* tests for continuous variables and chi-squared tests for binary variables. Values were considered significant if $P < .05$. Recorded complications included patellar maltracking (defined as subjective complaints of instability and >50% lateral overhang of patella on patellar view), extensor mechanism disruption, patellar fracture, and the need for reoperation or repeat revision of the patellar component.

Results

Management of the 304 aseptic revisions included retention of a well-fixed component in 212 (69.7%), revision using a standard all-polyethylene component in 46 (15.1%), resurfacing of a previously unresurfaced patella in 24 (7.9%), patelloplasty in 10 (3.4%), impaction grafting in 1 (0.3%), and extensor mechanism allograft in 11 (3.6%). Of the 46 patients who had a revision of the patellar component, the most common indications were a patellar-composite felt to be too thick (18; 39.1%), severe wear of an all-polyethylene patella (8; 17.4%), aseptic loosening of the patellar component (7; 15.2%), revision of a metal-backed patellar component with wear (5; 10.8%), and malpositioning of the patellar component (3; 6.5%). A lateral retinacular release was performed in 33 knees (10.9%).

Postoperative complications related to the patella occurred in 10 patients (3.3%). This included 3 patients with patellar maltracking (1.0%; 2 of which were associated with rupture of the medial arthrotoomy requiring surgical repair); 5 patellar tendon ruptures (1.6%) including 2 related to trauma (3 of which were treated with an extensor mechanism allograft and 2 with primary repair

Table 3
Clinical outcomes by management modality of patella in aseptic and septic revision TKA.

Outcomes	Preoperative	Postoperative	P value
Aseptic (n = 304) ^a			
Retention of patella (212)			
KSS knee	51.6 (14.4)	81.2 (17.7)	<.001
KSS function	37.6 (21)	58.2 (25.7)	<.001
Revision with standard component (46)			
KSS knee	48.3 (12.1)	79.8 (17.9)	<.001
KSS function	41.7 (17.9)	53.6 (28.9)	.009
Unresurfaced to standard component (24)			
KSS knee	51.1 (17.1)	66.9 (22.2)	<.001
KSS function	52.2 (10.4)	59.6 (22.2)	.27
Patelloplasty (10)			
KSS knee	47.0 (18.5)	83.3 (19.3)	<.001
KSS function	33.3 (19.2)	34.2 (29.6)	.92
Septic (n = 118) ^b			
Revision with standard component (88)			
KSS knee	48.5 (14.6)	80.4 (18.2)	<.001
KSS function	25.9 (23.1)	51.5 (34.0)	<.001
Patelloplasty (20)			
KSS knee	40.4 (18.6)	79.3 (17.9)	<.001
KSS function	30.6 (12.3)	33.2 (16.7)	.10

Values are means with standard deviation in parentheses.

^a Scores not presented for cases managed with extensor mechanism allograft (11) and impaction grafting (1).

^b Scores not presented for cases managed with patellectomy (7) and less used modalities (porous metal component [2] and gull-wing osteotomy [1]).

including allograft augmentation); and 2 patellar fractures (0.7%) noted on postoperative radiographs (both with an intact extensor mechanism and thus managed nonoperatively). Two patellar components that were retained subsequently showed radiographic evidence of loosening (0.7%) but were asymptomatic. No knees required repeat revision of the patellar component.

Of the 118 2-stage exchanges for infection, a standard all-polyethylene component was used in 88 (74.6%), a patelloplasty in 20 (16.9%), a patellectomy in 7 (5.9%), a porous metal component in 2 (1.7%), and a gull-wing osteotomy in 1 (0.9%). There were 45 lateral releases (38.1%). Complications related to the patella occurred in 8 patients (6.8%). This included 4 patients with patellar maltracking (3.4%; 1 requiring subsequent lateral release and the others were treated nonoperatively); 3 ruptures of the extensor mechanism (2.5%; 1 patellar tendon avulsion after a fall which was directly repaired to the tibial tubercle, 1 patellar tendon rupture treated with a knee arthrodesis, and 1 minimally symptomatic quadriceps tendon rupture treated nonoperatively); and 1 periprosthetic patellar fracture (0.9%; treated with operative excision of loose fragments and retention of the well-fixed patellar component). Two additional patients eventually required knee arthrodeses for persistent infection. None of the patellar components showed radiographic evidence of loosening, and no knees required repeat revision of the patellar component.

In the aseptic group, the KSS knee improved from a preoperative mean of 50.5 points to 81.0 points ($P < .0001$) and the function score improved from a mean of 38.2 points to 56.7 points ($P < .0001$) at a mean of 42 months postoperatively (range, 24–144 months; Table 3). Patients in whom the patellar component could be retained or replaced had better functional outcomes than patients who underwent patelloplasty (mean KSS function 58.2 vs 34.2 points; $P < .0001$). There was no difference in outcomes when a previous patellar component was retained compared with when a component was revised (mean KSS function 58.2 vs 53.6 points; $P = .210$).

Table 4
Comparison of demographics, patellar management, and outcomes for aseptic vs septic revisions.

Parameter	Aseptic (n = 304)	Septic (n = 118)	P value
Mean number of knee operations before revision	1.3 (0.54)	2.2 (0.8)	<.0001
Mean ASA score	2.5 (0.56)	2.6 (0.64)	.83
Lateral releases at index surgery, n (%)	33 (10.9)	45 (38.1)	<.02
Patients with postoperative complications related to patella, n (%)	10 (3.3)	6 (6.8)	.40
Mean pre KSS knee	50.5 (14.7)	47.7 (15.2)	.04
Mean post KSS knee	81.0 (13.2)	79.7 (14.5)	.96
Mean improvement KSS knee	30.5 (25.5)	32 (23.3)	.96
Mean pre KSS function	38.2 (10.8)	24.5 (13.6)	.04
Mean post KSS function	56.7 (26.3)	49.1 (24.1)	.05
Mean improvement KSS function	25.6 (15.9)	21.5 (25.3)	.40

ASA, American Society of Anesthesiologists Physical Classification System; post, postoperative at most recent follow-up; pre, preoperative.

Parentheses contain standard deviation unless percentage is specified.

In the septic cohort, the overall KSS improved from a mean of 47.7 to 79.7 points ($P < .0001$) at a mean of 41.1 months (range, 24–112 months), while the KSS function improved from a mean of 24.5 to 49 points ($P < .0001$; Table 3). Patients in whom the patella was successfully reconstructed had higher functional scores than those in whom a patelloplasty was performed (mean KSS function 51.5 vs 33.2 points; $P = .05$). Similarly, when the 370 patients who received a patellar component in both the aseptic and septic groups were compared with the 30 patients in whom a patelloplasty was performed, the KSS functional outcomes were better in the group that had a patellar component (mean 52.2 vs 33.5 points; $P < .001$).

Compared with patients who underwent aseptic revisions, patients revised for deep infection had lower preoperative KSS and lower postoperative KSS function (Table 4). Patients with septic knees had undergone a significantly greater number of knee surgeries before the index reimplantation procedure compared with the aseptic revisions. A lateral release was required more frequently in the septic group. The septic group also had twice the frequency of patella-related complications, although this did not reach statistical significance with the sample size available for study.

Discussion

Despite the increasing number of RTKAs being performed today and forecasted for the future [1], there is limited literature discussing management of the patella both in the septic and aseptic setting. Patellar management can be challenging given the small size, tenuous blood supply, and numerous options for reconstruction. In the present study, we describe our approach to patellar management, which considered the stability, size, and position of the implanted patellar component, thickness and quality of remaining bone stock, and competence of the extensor mechanism (Table 2). Using this approach, the rate of reoperation for, or revision of, the patellar component postoperatively was low with no repeat revisions specifically performed for patellar component loosening and a low rate of radiographic evidence of patellar component loosening.

This study has several limitations that the reader should consider when interpreting our results. First, this study was retrospective in nature, and because quality of life scores (eg, Short Form-12 Health Survey) were not obtained preoperatively, we were unable to make a comparative assessment postoperatively. A specific measure of anterior knee pain was also unavailable. Nonetheless, we did demonstrate significant preoperative to postoperative improvement in pain and function KSS. Second, just

<4% of patients were lost to follow-up; although an acceptably low rate, if these cases were considered failures, our overall failure rate would be higher. Finally, we used a relatively simple radiographic assessment of patellar stability (migration as seen on plain radiographs). Although a consensus was reached among multiple observers to determine component loosening, it is unknown if some of the components were loose without showing evidence of migration.

For revisions in the absence of infection, we found that the most common form of patellar management was retention of a well-fixed component (69.7%; Type 1). Although this approach is commonplace in contemporary practice, results of this strategy have only been reported in 3 smaller studies to our knowledge, ranging in size from 34 to 202 knees [14–16], all with a similarly low rate of failure. Given the limited bone stock for further revisions once a well-fixed component is removed, especially if the remaining host bone will be <10 mm in thickness, our preference was to retain the implanted component unless there was severe wear, the patella component was metal backed with visible wear [4,17], the implanted component was grossly malpositioned or incorrectly sized, or if the patellar composite was overly thick. Although we did subsequently note loosening of 2 retained patellar components, both of these were retained, and the overall prevalence of this complication was quite low (0.7%). We thus still believe that in the majority of aseptic RTKAs, the risks of patellar component retention are outweighed by the benefits [14,15].

In cases where the patellar component needed to be revised, either secondary to loosening or failure to meet the aforementioned criteria for retention (Type 2a), the majority of time a standard 3-pegged all-polyethylene component was utilized successfully. Our criteria for using this type of a standard component included adequate remaining host bone (>10 mm in thickness) and adequate remaining cancellous bone to provide some inherent stability with the trial in place and to accept cement for interdigitation to enhance long-term fixation. This technique is simple and familiar to most surgeons [3,5,14,18] and was applicable to more than two-thirds of cases where revision of the patellar component was required. None of these components subsequently required revision or became radiographically loose.

When there was <10 mm of patellar remnant and/or we were unable to obtain stability with a standard 3-peg component (Type 2b), specialized reconstructive techniques were required. Reconstructive options in these cases include the use of impaction grafting [9] or the use of a porous metal patellar component [6–8]. Another option was the so-called “gull-wing osteotomy” (a longitudinal split of the patellar fragment) which aims to improve the problems of lateral tracking seen in a resection arthroplasty by creating a concave shape that may be captured more readily in the trochlear groove. This technique is simple, but it has only been studied in small series [10,11] with promising early results. Although resection arthroplasty of the patella was an option, it has a relatively high incidence of persistent anterior knee pain and lateral patellar subluxation [14,19] and thus was used sparingly in our practice. If the patella was severely fragmented secondary to osteonecrosis but the extensor mechanism was intact (Type 3), management was difficult as it was a challenge to obtain central tracking of the extensor mechanism. Fortunately, this entity was rare, as outcomes in our experience were modest at best. Finally, when the extensor mechanism was not intact, it was reconstructed with an extensor mechanism allograft [20]. Although short-term results of this technique are encouraging, longer term prognosis remains unclear.

In the setting of 2-stage revision for infected TKA, using the same treatment algorithm as above, we found that 75% of patellae could be resurfaced with a standard all-polyethylene component

while most others were managed with patelloplasty (17%) because of limited bone stock, with specialized techniques used sparingly. This mirrors data from the 1 study to our knowledge to specifically examine patella care in 2-stage revisions; in a series of 66 2-stage revisions for infection, Glynn et al [21] reported resurfacing the patella with a new implant in 78% of cases, leaving the patella unresurfaced (ie, patelloplasty) 12.9% of the time, and using a trabecular metal augment, impaction grafting, or patellectomy on rare occasion. A lateral retinacular release was performed in 38% of cases in our septic group vs 14.5% in that series. However, Glynn et al only included patients without any TKA revisions before or after the index 2-stage procedure, potentially limiting surgical burden and scarring of the knee that could contribute to need for lateral release. Patellar maltracking and reoperation rates related to the patella or extensor mechanism were not reported for comparison; however, our rates of 3.4% and 3.4%, respectively, appear on par with prior studies to evaluate resurfacing of the patella in groups of mostly aseptic revisions, in which bone stock is often superior [18,22].

Similar to prior studies evaluating various treatment modalities for the patella in the revision setting, we noted significantly improved functional scores in both aseptic [6,9,15,23,24] and septic [22,24] cohorts. Like Barrack et al [14], in our aseptic cohort, we noted no difference in KSS outcomes with retention of the patellar component vs revision to a new component. We did, however, find higher functional scores when a patella component could be retained or placed at the time of revision surgery compared with that when it could not be. This corroborates earlier work by Barrack et al [18] and contrasts with the more recent work by Masri et al [25], which found no difference in functional outcomes with patelloplasty vs retention or resurfacing of the patellar component in a series of 110 revision TKAs (61 aseptic and 49 septic 2-stage revisions). In our septic cohort, like Glynn et al [21], we found that patients who received patellar resurfacing with a standard polyethylene component at reimplantation obtained higher postoperative KSS function compared with those in whom a patelloplasty alone was performed and the patella was not resurfaced.

In comparing the aseptic revisions with 2-stage reimplantations for infection, the infected cohort had lower KSS before surgery and lower postoperative KSS function at most recent follow-up. The inferior KSS preoperatively and postoperatively may reflect a higher burden of comorbidities not captured by American Society of Anesthesiologists score or may be the result of being multi-operated and having a worse overall outcome. Interestingly, Patil et al [16] found that among patients who underwent patellar resurfacing, patients revised for infection had greater improvements in KSS and Short Form-36 mental score. This was not the case in our study. We also found that septic cases required a much higher rate of lateral releases at the time of surgery, which in our practice is used to improve exposure and patellar tracking and once again reflects the difficulty in managing these complex patients who have often undergone multiple surgeries and have sometimes been immobilized during the course of staged revisions. Patients who underwent revisions for infection had twice the rate of complications related to the extensor mechanism; however, with our sample size, this did not reach statistical significance.

Conclusions

Although treatment of the patella at the time of RTKA can be challenging, our classification system can assist the surgeon in determining appropriate management. In the majority of aseptic RTKAs, a well-fixed patellar component can be retained (Type 1). If revision is required in the aseptic or septic setting, a standard cemented all-polyethylene component is usually sufficient (Type

2a). Specialized techniques exist but should be reserved for cases of severe bone loss and/or an incompetent extensor mechanism. Using the approach described, we observed a low rate of reoperations and rerevisions related to the patellar component.

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