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Decreased Patellar Fractures and Subluxation With Patellar Component Replacement at Stage-One Spacer

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ABSTRACT

Background: Periprosthetic joint infection is a devastating complication of total knee arthroplasty and is often treated with 2-stage revision. We retrospectively assessed whether replacing the patellar component with articulating stage-one spacers was associated with improved outcomes compared to spacers without patellar component replacement.

Methods: A total of 139 patients from a single academic institution were identified who underwent an articulating stage-one revision total knee arthroplasty and had at least 1-year follow-up. Of the 139 patients, 91 underwent patellar component removal without replacement, while 48 had a patellar component replaced at stage-one revision. Patellar fracture and reinfection at any point after stage-one were recorded. Knee range of motion (ROM), patellar thickness, lateral tilt, and lateral displacement were measured at 6-weeks post stage-one. *Chi*-square, Fisher's exact, and *t*-tests were utilized for comparisons. There were no significant demographic differences between groups.

Results: Patellar component replacement at stage-one revision was associated with fewer patellar fractures (2.1 versus 12.1%, $P = .046$), less lateral patellar displacement (1.7 versus 16.0 mm, $P < .01$), and improved pre to postoperative knee ROM 6 weeks after stage-one (+5.9 versus $-11.4°$, $P = .03$). There was no difference in reinfections after stage-2 revision for the replaced or unreplaced patellar groups (15.4 versus 15%, $P = 1.000$). While the mean time between stage-one and stage-2 was not different (5.2 versus 4.5 months, $P = .50$), at one-year follow-up, significantly more patients in the patellar component replacement group were satisfied and refused stage-2 revision (45.8 versus 3.3%, $P < .001$).

Conclusions: Replacing the patellar component at stage-one revision is associated with a decreased rate of patellar fracture and lateral patellar subluxation, improved ROM, and possible increased patient satisfaction, as reflected by nearly half of these patients electing to keep their spacer. There was no difference in reinfection rates between the cohorts.

Total knee arthroplasty (TKA) remains one of the most common orthopedic procedures in the United States, with current projections exceeding 1.9 million cases per year by 2030 [1,2]. As the volume of primary TKAs continues to rise, the total number of complications is also expected to increase [3–8]. Periprosthetic joint infection (PJI) is a devastating complication following TKA and remains the most common cause for revision knee surgery, according to the American Joint Replacement Registry [9]. In 2021, PJI comprised approximately 30.9% of indications for all revision knee arthroplasties performed in the United States [9]. Additionally, PJI is associated with major morbidity and mortality in patients and endures a substantial financial burden to hospitals, with an estimated $1.62 billion annually on the US healthcare system [10–14].

In 1983, Dr. Insall introduced 2-stage revision surgery for the eradication of PJI [15]. Stage-one consists of removal of infected hardware, extensive debridement, and the placement of an antibiotic-loaded spacer. Patients then receive at least 6 weeks of systemic antibiotics, followed by confirmation of infection

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eradication. The second stage involves the removal of the antibiotic-loaded spacer and the implantation of definitive implants [16]. A 2-stage revision knee arthroplasty remains the gold standard for the treatment of knee PJIs in the United States, with an overall success rate of 72 to 89% [17,18].

Whether to resurface the patella in primary TKA is a highly debated topic [19–22]. Although investigation into whether to resurface the patella at stage-2 revision TKA has been performed, to our knowledge to date, there is no literature examining the role of patellar resurfacing at the time of stage-one spacer placement [23,24]. The aim of this study was to retrospectively assess if replacing the patellar component during articulating stage-one spacers was associated with improved outcomes compared to stage-one articulating spacers without patellar component replacement. We hypothesized that replacement of a removed patellar component at stage-one knee revision would correlate with decreased patella fracture rates and lateral patellar subluxation with no difference in reinfection rates.

Methods

A retrospective review was performed on a consecutive series of patients who underwent stage-one revision TKA at a single academic tertiary referral center from September, 1, 2013 to September, 1, 2022. A total of 139 patients were identified who underwent a metal-on-polyethylene articulating stage-one spacer, had an intact extensor mechanism, and had at least 1 year of follow-up after stage-one revision. Exclusion criteria consisted of patellectomy prior to stage-one revision, an unresurfaced patella at primary total knee arthroplasty, pre-existing patellar fracture or fragmentation prior to undergoing stage-one revision, the use of a static spacer, or follow-up less than 1 year after stage-one revision. In 2020, 2 of the senior authors (JMG and LAA) began routinely reimplanting the patellar button at stage-one revision, given concerns that an unprotected patella after the original patellar component had been removed would increase fracture or thinning of the patellar bone stock between stages of the 2-stage process. This involved the removal of the polyethylene patellar component at stage-one revision arthroplasty and then cementing on a new all-polyethylene patellar component as part of the antibiotic loaded metal on polyethylene articulating spacer. In order to avoid an extremely well fixed patellar component at the time of second stage revision, we placed the patellar component with drying cement and attempted to obtain loose macrofixation of cement into the patellar bone. This provided a patellar component that could be easily removed with minimal bone loss, at subsequent second stage revision. This was achieved by applying bone cement while in the doughy phase and avoiding pressurizing cement on the patella bone. We refer to this technique as “loose macrofixation” of the patellar component to the patella and have found that it makes removal of the patellar component at stage-2 revision much easier without causing further patellar bone loss.

All of the 139 included patients presented with infected primary TKAs with previously resurfaced patellae and all underwent a stage-one articulating spacer during which they had removal of the original femoral component, tibial component, and patellar component and then underwent a meticulous debridement of infected tissue and bone. The stage-one spacer was then constructed using a new metal femoral component, a new all-polyethylene tibial component, and antibiotic loaded cement dowels that were placed in the canals of both the tibia and femur. These components were cemented into place using antibiotic loaded cement with a standard mixture of 3.2 g of tobramycin and 2 g of vancomycin per single 40 g batch of high-viscosity cement. 91 of these patients had nothing placed on the backside of the patella where the old patellar component had been removed, while 48 of these patients had a new polyethylene patellar component cemented onto the backside of the patella using the same antibiotic loaded cement.

Rates of patellar fracture, reinfection after stage-2 revision, and repeat stage-one revision were all analyzed, with failure defined as a recurrence of infection after stage-2 or the need for a repeat stage-one spacer after the first stage-one spacer. Additionally, knee range of motion (ROM), presence of extensor lag greater than 10°, patellar thickness, lateral displacement, and lateral tilt were measured at 6 weeks poststage-one revision. Radiographic measurements were performed on postoperative Merchant-view radiographs using a standardized protocol [25]. Demographic and comorbidity data between these 2 groups were collected and are summarized in Table 1. There were no significant differences in demographic variables between these 2 groups. However, the length of follow-up was significantly greater in the group that did not have their patellar component replaced at stage-one revision (41.2 versus 18.8 months, $P < .001$) given that this was our historical cohort. Statistical analyses were performed using SAS 9.4. *Chi*-square and Fisher’s exact tests were used for categorical variables, and independent *t*-tests were utilized for continuous variables.

Results

Radiographic Outcomes

Replacing the patellar component at stage-one revision was associated with a decreased rate of patellar fracture (2.1 versus 12.1%, $P = .046$) and less lateral patellar displacement (1.7 versus 16.0 mm, $P < .01$) (Table 2). Figure 1 demonstrates increased lateral patellar displacement and fracture in the non-replaced patellar component group as opposed to a patella that underwent component replacement at stage-one revision. Patients who had their patellar component replaced, on average, had significantly thicker patellae after both stage-one and stage-2 revisions than those who did not have their patellar component replaced (Table 2). The mean decrease in patellar thickness from stage-one to stage-2 was significantly greater for those without patellar component replacement (−1.0 versus −0.1, $P < .001$). Additionally, significantly more patellae were determined to be too thin to be resurfaced (< 10 mm) at the time of the second-stage revision in the group without patellar component replacement at stage-one (21.25 versus 0%, $P = .02$), (Figure 2). No patellar components were displaced or dislodged upon radiographic review of the patellar component arthroplasty cohort. Additionally, operative reports of stage-2

Table 1
Patient Demographics.

	Patellar Component Removal without replacement (N = 91)		Patellar Component Removal and replacement (N = 48)		P Value
	Mean (Std)		Mean (Std)		
Age	62.2 (9.5)		64.9 (9.8)		.1264
BMI	34.4 (8.5)		32.1 (6.9)		.1158
ASA	2.8 (0.5)		2.6 (0.6)		.0871
		N (%)		N (%)	P Value
Sex					
Women		41 (45.1)		18 (37.5)	.3915
Men		50 (55.0)		30 (62.5)	
Smoker					
No		57 (62.6)		29 (60.4)	.7977
Yes		34 (34.4)		19 (39.6)	

std, standard deviation; BMI, body mass index; ASA, American society of anaesthesiologists’ classification of physical health.

Table 2
Radiographic Review of Patellae at 6 Weeks after Stage-One Revision.

	Stage-1 Revision Without Patellar Component Replacement (N = 91)	Stage-1 Revision With Patellar Component Replacement (N = 48)	*P* Value
	Mean (Std)	Mean (Std)	
Patellar fracture	11 (12.09)	1 (2.1)	.046
Lateral Patellar Displacement	16.1 (10.7)	1.7 (3.7)	<.0001
Patellar Tilt	4.7 (7.6)	3.0 (3.6)	.142
Patellar Thickness (lateral)	14.0 (2.5)	15.1 (1.7)	.003
Patellar Thickness (sunrise or merchant)	15.0 (2.0)	15.8 (1.7)	.039

Std, standard deviation.

revisions indicated no dislodged patellar components for those who underwent patellar component replacement at stage-one revision.

Clinical Outcomes after Stage-One Revision

Pre to postoperative knee ROM at 6 weeks status post stage-one revision improved significantly more for those who had their patellar component replaced (+5.9 versus −11.4°, $P = .03$). Preoperative knee ROMs were not significantly different between those without patellar component replacement and those with patellar component replacement, respectively (103.9 ± 21.1 versus 99.3° ± 2 9.6, $P = .47$). There was a non-significant trend toward more extensor lag greater than 10 degrees in the group without patellar component replacement at stage-one (14.3 versus 4.2%, $P = .068$), and there was a significantly increased rate of repeat spacers in the stage-one revision group without patellar component replacement (8.8 versus 0%, $P = .034$). These findings are summarized in Table 3. Also, patients who underwent patellar component replacement at stage-one revision were more likely to elect to keep their spacer, despite being offered stage-2 revision (45.8 versus 3.3%, $P < .001$).

Clinical Outcomes after Stage-2 Revision

When evaluating outcomes after stage-2 revision arthroplasty, there were no significant differences in need for extensor mechanism reconstruction, presence of extensor lag, extensor mechanism failure after stage-2, or recurrent infections between those who did and did not have their patellar component replaced at stage-one. These findings are summarized in Table 4. While the mean time between stage-one and stage-2 was not significantly different (5.2 versus 4.5 months, $P = .50$), at 1-year follow-up, significantly more patients in the patellar component replacement group refused stage-2 revision (46 versus 3.3%, $P < .001$), Figure 3. Also, there was a significant increase in the rate of being unable to resurface the patella at stage-2 revision due to a patellar thickness less than 10 mm in the nonreplaced patellar component group (21.25% in the nonreplaced patellar component group versus 0% in the replaced patellar component group, $P = .02$), Figure 4.

Discussion

This retrospective study supports that replacement of a patellar component at stage-one of a 2-stage revision knee arthroplasty for PJI is associated with decreased rates of patellar fracture and decreased lateral patellar subluxation between stage-one and stage-2 revision. Additionally, there appears to be improved knee ROM with stage-one spacers in place and higher rates of being able to reimplant the patellar component at stage-2 revision when the patellar component is replaced at stage-one. While we placed the patellar component during stage-one revision in such a way as to be able to remove it with minimal bone loss during subsequent stage-2 revision, not all of these ultimately were truly temporary implants, as more patients in the replaced patellar component group ultimately elected to maintain their functional stage-one spacer indefinitely. Though we did find a higher rate of need for repeat spacer in the group without patellar component replacement at stage-one, there did not appear to be any difference in infection recurrence rates after stage-2 revision when a patellar component was replaced at stage-one revision. Although there is literature examining the role of patellar reresurfacing at stage-2 revision knee arthroplasty, to our knowledge, this study is the first to examine the impacts of replacing the patellar component during stage-one revision [23,24].

Despite the increasing magnitude of primary TKAs and subsequent PJIs in the United States, there is limited literature on the management of the patella during 2-stage revision arthroplasty for PJI. Buller et al. examined 103 patients undergoing 2-stage revision after PJI [24]. All patients had their patellar components removed at stage-one, and 80% of patients received an articulating spacer. Patellae were resurfaced at stage-2, if there was greater than 10 mm of bone stock present. A total of 42% of patellae were reresurfaced,

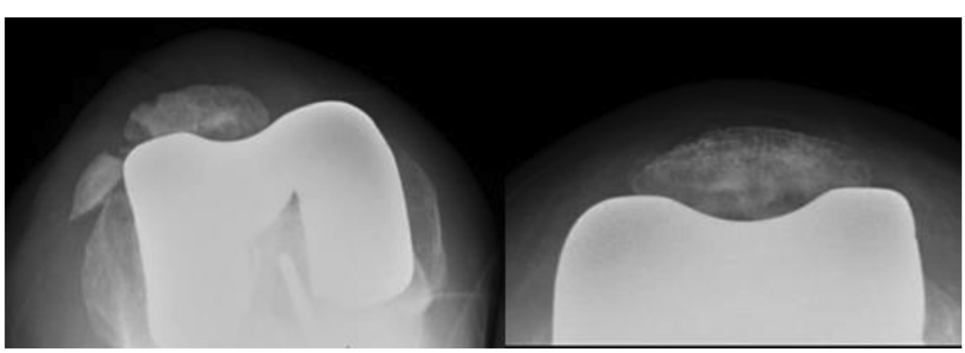

Fig. 1. Example of increased lateral patellar displacement and fracture in a non-replaced patellar button (Left) versus a replaced patellar button at stage-one revision (Right).

Table 3
Outcomes After Stage-One Revision.

	Patellar Component Removal without replacement (N = 91)	Patellar Component Removal with replacement (N = 48)	*P* Value
	Mean (Std)	Mean (Std)	
Range of motion			
Preoperative	103.9 (21.1)	99.3 (29.6)	.470
6 wk postoperative	88.7 (29.1)	103.6 (20.7)	.006
Change from preop to 6 wk	−11.4 (29.6)	5.9 (37.3)	.029
	N (%)	N (%)	*P* Value
Extensor lag	13 (14.3)	2 (4.2)	.068
Repeat stage-one revision	8 (8.8)	0 (0.0)	.034

Std, standard deviation.

and 58% were not. Patient-reported outcomes and implant survivorship did not improve with reresurfacing. However, greater than 4 mm of lateral patellar displacement was seen in 66% of patients who did not have a patellar component after 2-stage revision, as opposed to only 30% of patients who had a reimplanted patellar component at the second-stage revision. These findings are also consistent with our study, which demonstrated decreased lateral patellar displacement when the patellar component was re-resurfaced at stage-one revision. Additionally, Joo et al. evaluated 48 patients (49 knees) who underwent 2-stage revision for PJI, but had unresurfaced patellae at primary TKA [23]. There were 23 knees that underwent patellar resurfacing at stage-2, while 26 knees were managed without patellar resurfacing. There were no significant differences in anterior knee pain, infection recurrence, or Western Ontario and McMaster University Osteoarthritis index and Knee Society scores. Radiographic outcomes were not reported. The defining difference in this patient population versus our study's patient population is the presence of a previously resurfaced patella at primary TKA in all of our patients, so limited comparisons can be made.

An additional finding in our study was that patients who underwent patellar component replacement at stage-one revision were more likely to keep their spacer, despite being offered 2-stage revision. Although these findings are likely multifactorial, this may suggest that patients are more satisfied with the function of the spacers where the patellar component was replaced compared to those where it was not. Based on our radiographic review, we hypothesized that the lateral subluxation of the flat, unprotected patella after stage-one revision caused edge loading of the patella and increased stress on this sesamoid bone. We believe that this is likely the mechanism by which there is an increased rate of patellar fracture in the unreplaced patellar component cohort. Additionally, patients who had a stage-one spacer with a replaced patellar component had improved knee ROM and a trend toward less extensor lag compared to the unreplaced group. This may play a role in patient satisfaction with their stage-one spacer. However, the overall finding of more patients electing to keep their stage-one spacer when their patellar button was replaced must also be interpreted based on the significantly shorter follow-up in this cohort. The mean follow-up time was 18.8 months in the replaced patellar component group as opposed to 41.2 months in the non-replaced group ($P < .001$), and this difference in follow-up cannot be ignored. However, in support of our findings is the fact that there was no significant difference in time between stage-one and stage-2 revision when comparing the 2 cohorts (5.2 versus 4.5 months, $P = .50$). Since the average follow-up of both cohorts exceeds the typical time between stage-one and stage-2 revision, there is support that adequate follow-up occurred to rule out patients becoming dissatisfied with their stage-one spacers.

One possible concern about replacing the patellar button at stage-one revision is that there may be an increased risk of infection. In our study, there was no increased risk of reinfection for those who had their patellar button replaced at stage-one revision versus those who did not. The particular limitation of the study is the significantly shorter follow-up time in the replaced patellar button group, as previously mentioned. However, there appears to be sufficient follow-up to capture the majority of those who would eventually go on to recurrent PJI. Pulido et al. reviewed nearly 10,000 patients undergoing primary hip or knee arthroplasty [26]. The majority of PJI was diagnosed within the first year of surgery, accounting for 65%, or 41 of the 63 infections. It was noted that the average time of diagnosis for PJI was 431 days after index surgery. The McMaster Arthroplasty Collaborative reviewed over 100,000 patients undergoing total hip arthroplasties and noted that nearly half of all PJIs occur within one year after the surgical procedure [27]. Therefore, it appears that although our follow-up is less in the replaced patellar button group, it is still sufficient to capture the majority of recurrent PJIs that should occur based on the available literature. However, further long-term outcomes still need to be collected to make a more definitive conclusion.

Table 4
Outcomes After Stage-2 Revision.

	Stage-1 Revision Without Patellar Component Replacement (N = 80)	Stage-1 Revision With Patellar Component Replacement (N = 26)	*P* Value
	N (%)	N (%)	
Need for extensor mechanism reconstruction at stage-2 revision	5 (6.3)	0 (0)	.331
Extensor lag after stage-2 revision	7 (8.9)	1 (3.9)	.676
Extensor mechanism failure after stage-2 revision	1 (1.3)	0 (0)	1.000
Recurrent infection	12 (15.0)	4 (15.4)	1.000
	Mean (std)	Mean (std)	*P* Value
Time from stage-one to stage-2 revision	4.5 mo (3.0)	5.2 mo (4.6)	.383

Std, standard deviation.

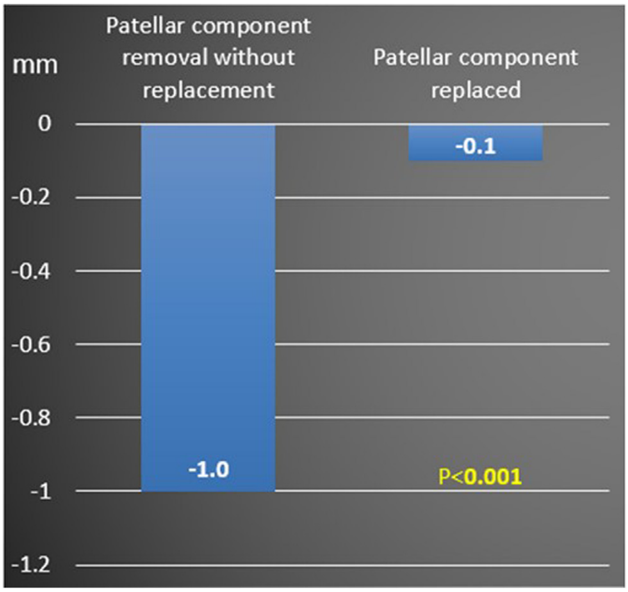

Fig. 2. Change in mean patella thickness from stage-one to stage-2 revision *P* < .001.

As previously discussed, this retrospective study has several potential limitations that must be highlighted. The number of PJIs that met inclusion criteria was limited to 139 patients. Although this study was conducted at the largest tertiary referral center in our multistate region, the number of cases is limited, and difficulty with follow-up persists in this population. Additionally, there are inherent differences in mean follow-up times for the 2 patient cohorts, as described above. This may spuriously lower the overall reinfection rate, but given the current amount of patient follow-up collected, we believe that the majority of recurrent PJIs should be captured, as discussed previously. However, we cannot be definitive on this claim until further long-term data are collected on patients who underwent patellar component exchange at stage-one revision.

Also, one may conjecture that the nonresurfaced patella cohort represents patients who have thinner and more fragile patellae than those who underwent patellar component replacement at stage-one revision. At our institution, we were not reresurfacing

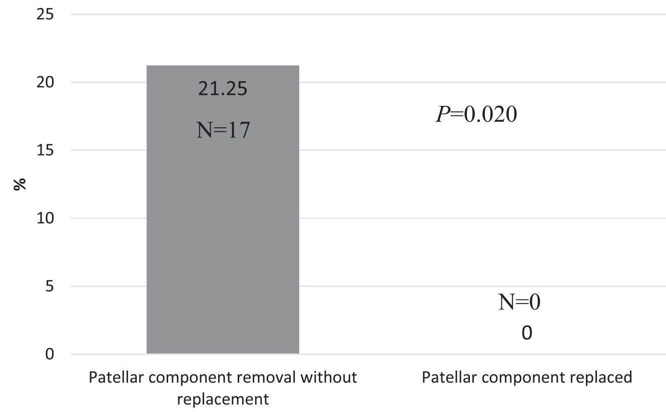

Fig. 4. Patellae too thin to be resurfaced at stage-2 revision (<10 mm) N = 17 N = 0.

patellae at stage-one revision prior to 2020. Additionally, upon reviewing all operative reports of the nonresurfaced cohort, only 4 operative reports made mention of thin patellae. None of these patellae went on to fracture, and all 4 had a radiographic thickness > 12 mm measured on preoperative lateral radiographs. Additionally, 2 of these patients were able to be resurfaced at second-stage revision. Additionally, we reviewed patient patellar thickness prior to stage-one of the nonresurfaced cohort. Only one patient had a patellar thickness less than 12 mm, which was measured at 10.7 mm. This patient did not go on to fracture and was able to be resurfaced at stage-2 revision. Therefore, we believe that selection bias is low in the non-replaced cohort and serves as an appropriate comparison to the cohort of patients who underwent patellar component replacement at stage-one revision.

Conclusions

Replacing the patellar component at stage-one is associated with decreased rates of patellar fracture and subluxation, thicker patellar bone stock at stage-2 revision, higher rates of reimplantable patellar bone stock at stage-2, improved knee ROM with a stage-one spacer in place, and no difference in reinfection rates. This study's main limitations are its retrospective nature and the shorter follow-up in the reimplanted patellar button group, which may underestimate rates of reinfection in the long term.

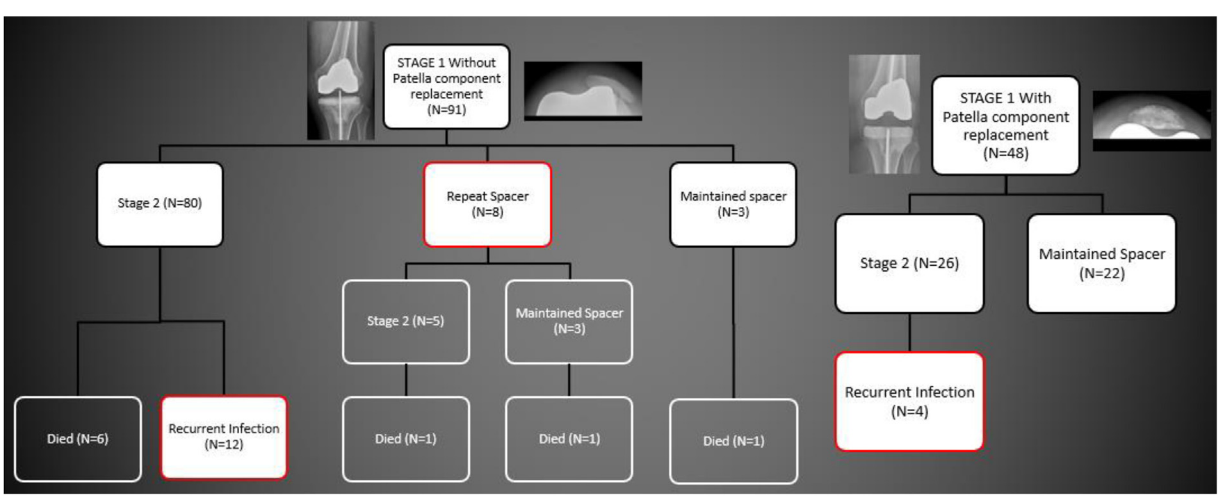

Fig. 3. Flowchart of patient outcomes for stage-one revisions with or without patellar button replacement.

CRediT authorship contribution statement

Joshua P. Rainey: Writing – review & editing, Writing – original draft, Data curation. **Brenna E. Blackburn:** Writing – review & editing, Methodology, Formal analysis, Data curation. **Zachary J. Moore:** Writing – review & editing, Data curation. **Michael J. Archibeck:** Writing – review & editing, Conceptualization. **Christopher E. Pelt:** Writing – review & editing, Conceptualization. **Lucas A. Anderson:** Writing – review & editing, Conceptualization. **Jeremy M. Gililland:** Writing – review & editing, Supervision, Investigation, Conceptualization.

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