Joint line and patellar height restoration after revision total knee arthroplasty

Jong-Keun Seon, Eun-Kyoo Song

Abstract

Background: Restoration of proper joint line (JL) position and patellar height in revision total knee arthroplasty (TKA) is essential in the recovery of knee function and kinematics. We determined whether the JL position and patellar height could be restored in patients undergoing septic and aseptic revision TKA.

Materials and Methods: We retrospectively reviewed 70 patients (74 knees) who had revision TKA between September 2004 and December 2010. Forty seven knees had a two stage revision for infected TKA and 27 knees for aseptic failure. The JL position, patellar height and patellar tendon (PT) length were measured and compared between primary TKA and post revision. The clinical scores including a hospital for special surgery (HSS), Knee Society Score (KSS), Western Ontario and McMaster Universities (WOMAC) and range of motion (ROM) were compared.

Results: The overall JL increased from 17.51 mm to 18.37 mm post revision, the Insall-Salvati (IS) ratio declined from 0.98 to 0.92, and the PT length declined from 42.92 mm to 39.45 mm. 9 of the 21 patellar baja knees improved to normal patellar height. After revision, the JL in the septic group (17.02 mm) was significantly lower than the aseptic group (20.74 mm). The changes of the JL position and IS ratio in the septic group were significantly larger than the aseptic groups ($P < 0.05$). JL position had a positive correlation to the IS ratio and PT length post revision. The knee function scores including HSS, KSS, WOMAC scores, and ROM all improved post revision compared to pre revision ($P < 0.05$), and the septic group had a lower knee function compared to the aseptic group. JL position and IS ratio post revision had no correlation to the HSS, KSS, WOMAC scores, and ROM.

Conclusions: JL position can be sufficiently restored with appropriate distal femoral augment reconstruction after revision TKA, but the patellar height cannot be well improved, especially in the septic revision with obvious PT contracture. No correlation was found between the JL position and patellar height to the knee function post revision TKA.

Key words: Joint line, knee function, patellar height, revision, total knee arthroplasty
MeSH terms: Arthroplasty, replacement, knee, osteoarthritis, knee prosthesis

Introduction

Revision total knee arthroplasty (TKA) accounts for 5–10% of all knee replacements,[1] prosthesis loosening and instability are two main reasons for revision. The number of TKA revisions have shown a steady increase due to the rapidly increased primary TKA surgeries.[2,3] Revision TKAs not only cause a financial burden with more medical costs,[4,5] but also form a technical challenge for the surgeons compared to primary TKA, requiring a good understanding of kinematics reconstruction to achieve optimum knee alignment and function.[6-10]

The importance of joint line (JL) and patellar height restoration in revision TKA had already been established. Malposition of the JL can lead to decreased extensor strength, patellar impingement and anterior knee pain, patellar instability and decreased range of motion (ROM).[8,11,12]

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Therefore, restoration of patellar height and JL is of vital importance to achieve better clinical and functional outcomes in revision TKA. Many methods have been proposed to estimate the JL pre or after revision surgery.[13-15] However, with severe bone loss and soft tissue pathological changes, surgeons usually fell in a dilemma of restoring JL and patellar height position and maintain knee stability, implants stability simultaneously. With the selective augments provided by modern knee revision systems, reconstruction of the distal femoral bone deficiency to restore JL position can be well resolved,[11] but the patellar height and patellofemoral joint kinematic restoration were still the big challenges to revision TKA.

Our aim in this study was to review the JL and patellar height changes post septic and aseptic revision TKA. The hypotheses of this study were: (1) JL can be accurately restored in revision TKA with adequate augmentation. (2) Patellar height can be well improved with the JL position restoration. (3) JL position and patellar height had no difference post revision in septic and a septic knee revisions. (4) JL position and patellar height were correlated to improve the knee function post revision TKA.

Materials and Methods

80 cases (85 knees) that underwent revision TKA at our institution between September 2004 and December 2010 were included in this retrospective study. Of the 85 patients, 10 cases (11 knees) were excluded from study, 2 cases (2 knees) performed tumor implants revision, 2 cases (2 knees) only performed bearing changes, 3 cases (3 knees) only underwent tibia tray revised and 3 cases (4 knees) had inadequate radiographs to evaluate.

Finally 70 cases (74 knees) were included in the study, there were 13 men and 57 women, with an average age of 68.79 years (range 48–90 years) at the time of revision surgery. Forty six cases (47 knees) underwent two-stage revisions with cement spacer for chronic deep periprosthetic infection, (8 cases underwent static antibiotic-loaded cement spacer and other 39 knees articulating spacer). Twenty four cases (27 knees) underwent single stage revision for aseptic reasons (aseptic group), including aseptic loosening 8 cases (8 knees) and multidirectional instability 16 cases (19 knees). There was no significant difference between the two groups ($P > 0.05$) [Table 1], as far as the gender, age, knee site and body mass index were concerned.

All the revision surgeries were performed by the senior surgeon (JKS). The exposure includes quadriceps snip and tibial tubercle osteotomy. The tibia reconstruction was performed first with an attempt to preserve the remnant bone, followed by the sizing of the femur and reestablishment of the flexion gap,[16] posterior femoral augmentations applied to reconstruct the posterior femoral offset. Appropriate tibia bearing was inserted to evaluate the flexion gap and balance. Then the extension gap was adjusted by distal or proximal displacement of the femoral component with appropriate distal femoral augment. Finally, femoral component and polyethylene insert size was determined by checking flexion and extension gap. Now, the JL position was evaluated, and the planned distance from the medial and lateral epicondylar to tibia bearing was 25–30 mm in extension state. Patellar tracking was tested with trials in position, the cases showed patellar subluxation, tilt, or maltraction undertaken lateral retinacular release. If the patellar baja or alta was found, the extensor mechanism was reconstructed by quadricepsplasty, distal, or proximal migration of the tibia tubercle; if serious patella baja exists, the JL was declined by increasing the distal femoral augmentation because of the large bone defect and declined bearing thickness to improve baja. All the revision knee prosthesis were implanted using bone cement fixation.

The exposure technique for the septic and aseptic group was all quadriceps snip. Forty seven knees in the septic group (100%) and 22 knees in the aseptic group (81.5%) performed augment reconstruction. In term of the distal femur, 52 knees (70.27%) underwent augment reconstruction, 38 knees (80.85%) in the septic group, and 14 knees (51.85%) in the aseptic group. The overall average medial and lateral femoral distal augment thickness were 5.34 mm (standard deviation [SD], 4.55), 5.12 mm (SD, 4.26), in the septic group they were 6.38 mm (SD 4.26) and 6.60 mm (SD 4.67); while in the aseptic group they were 2.93 mm (SD 3.32) and 3.15 mm (SD 3.40), respectively. The revision prosthesis used in this study was all constrained type, legacy constrained condylar knee (Nexgen, Zimmer, Inc., Warsaw, IN 46580, U.S.A) only.

All patients were evaluated preoperatively and at followup, including Knee Society Score (KSS), hospital for special surgery (HSS), Western Ontario and McMaster Universities (WOMAC) scores, and ROM. Two independent investigators, who were not involved in the surgery, measured the preoperative and postoperative radiographs (anteroposterior and lateral) to reduce

Table 1: Demographic details of the patients

Parameters	Septic group	Aseptic group	*P*
No. of knees	47	27	
Gender (male/female)	8/38	5/19	0.725
Age (years)	69.65±7.54	67.13±7.10	0.179
Knee site (left/right)	24/23	16/11	0.496
BMI (kg/m^2)	26.02±3.42	25.36±3.03	0.408

BMI=Body mass index, TKA=Total knee arthroplasty

observation bias. All radiographic measurements were checked with consistent distance according to the knee society roentgenographic evaluation system. If radiographs of the knee before primary TKA were not available, a comparison was made with the contralateral knee without TKA. JL position was measured from the distal part of the lateral femoral condyle[15,17] to the top of the fibular head apex (FHJL) [Figure 1]. Patellar height was evaluated by Insall-Salvati (IS) ratio, which calculates the ratio between the patellar tendon (PT) length and diagonal length of the patella. We defined patellar baja as an IS ratio <0.80 and alta as a ratio more than 1.20.[18] A positive value indicated an increase from pre to postoperative in the measured values and reverse as negative. In this study, the intraclass correlation coefficients for all measurements were >0.8 for the intra and interobserver reliabilities.

Statistical analysis

Statistical analysis was performed using SPSS statistical software (17.0; SPSS, Chicago, Illinois, USA). The arithmetic mean, SD and distribution of values were determined for each group. Independent samples *t*-test was performed for comparison of arithmetic values between septic and aseptic groups and paired *t*-test was used to compare the values pre and post revision surgery. Proportions of categorical data were compared using Chi-square and Fisher exact tests. Pearson correlation analysis was performed on the relationship of JL, PT length, IS ratio and knee function. A *P* value of <0.05 was considered significant.

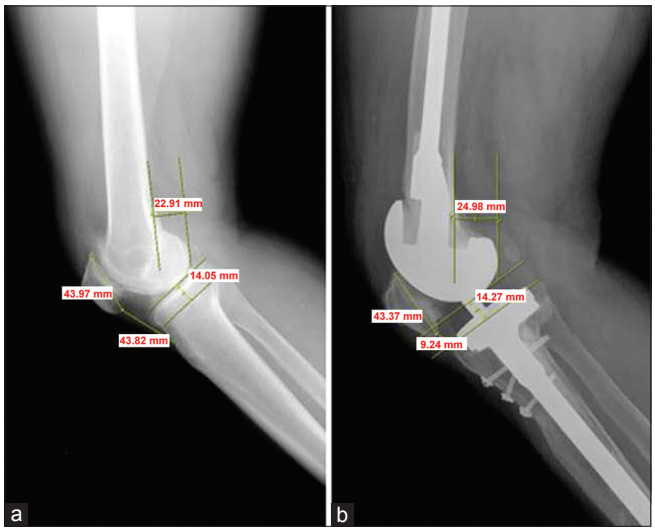

Figure 1: (a) Lateral radiographs of the knee before total knee arthroplasty. Joint line position is measured from fibular head to the lateral distal femoral condyle (Figgie's method) (b) lateral knee radiography postrevision. The Insall-Salvati ratio, joint line position, and patellar tendon length were measured

Results

Seventy cases (74 knees) were followed up for a mean period of 48.2 months (range 15-69 months). Except 1 patient who expired because of cardiovascular arrest after 2 years followup, no patients was lost to followup. The JL increased from 17.51 mm to 18.37 mm post revision [Table 2]. Twenty four knees (32.43%) had a JL change ≥5 mm, 14 knees in the septic group and 10 knees in the aseptic group. The ratio of JL change ≥5 mm in the two groups had no statistical difference ($P = 0.521$). The PT length significantly declined from 42.92 mm to 39.45 mm ($P = 0.004$). The IS ratio declined from 0.98 to 0.92, a significant difference was found between preprimary and post revision TKA ($P = 0.013$). Before revision TKA, 21 knees had patellar baja (septic 15 knees, aseptic 6 knees), 9 knees improved to normal patellar height post revision TKA ($P > 0.05$). Patellar alta 2 knees (septic group) had no improvement post revision.

In septic group, the mean JL declined from 17.47 mm to 17.02 mm post revision [Table 3], the changes had no statistical difference ($P = 0.566$). PT length significantly declined from 42.96 mm to 38.52 mm ($P = 0.006$). The mean IS ratio declined from 0.99 to 0.89 postoperative ($P = 0.003$). Patella baja knees decreased from 15 to 9 post revision without statistical difference ($P = 0.900$).

In aseptic group, the JL elevated from 17.56 mm to 20.74 mm postoperatively [Table 3], no significant difference was found ($P = 0.074$). PT length declined from 42.85 mm to 41.09 mm without significant difference ($P = 0.340$). The mean IS ratio increased from 0.96 to 0.97 ($P = 0.811$). Patella baja knees decreased from 6 to 3 post revision without statistical difference ($P = 0.834$).

After revision, the JL of the septic group was significantly lower than the aseptic group ($P = 0.013$). The IS ratio, PT length and patellar baja ratio post revision all had no

Table 2: The joint line and patellar height distribution of preprimary and post revision TKA

	Pre-TKA	Post revision	95% CI	Changes	*P*
JL (mm)	17.51±4.46	18.37±6.25	16.93-19.82	0.87±7.07	0.296
PT length (mm)	42.92±3.91	39.45±9.00	37.37-41.54	−3.47±1.18	0.004
IS ratio	0.98±0.13	0.92±0.23	−0.11-−0.01	−0.62±0.02	0.013
Patellar baja	21 (pre revision)	12	0.39-2.62	−9	0.984
Patellar alta	2 (pre revision)	2	0.074-4.188	0	0.564

JL=Joint line, TKA=Total knee arthroplasty, IS=Insall-Salvati, PT=Patellar tendon, CI=Confidence interval

statistical difference compared in the two groups ($P > 0.05$). The changes of the JL position and IS ratio in the septic group were significantly larger than the aseptic groups ($P < 0.05$). The decrease number of patellar baja and the changes of PT length had no statistical difference between the two groups ($P > 0.05$).

There was a significant improvement in overall functional status as determined by HSS, KSS, WOMAC scores and ROM [Table 4]. In the septic group, the HSS, KSS, WOMAC scores and ROM were 41.26, 61.59, 61.59, and 54.96 points preoperatively, and postoperatively they changed to 71.74, 124.30, 38.71, and 95.43 points, respectively, all the values had significant difference compared to preoperative ($P < 0.05$). In the aseptic group, the preoperative HSS, KSS, WOMAC scores, and ROM were 51.56, 98.06, 60.26 and 106.11 points and they significantly improved to 82.00, 143.37, 24.50 and 119.12 points, respectively ($P < 0.05$). But when we compared the four values pre revision, only the WOMAC score had no significant difference, the HSS, KSS, and ROM all had a statistical difference ($P < 0.05$), the septic group had a lower score than the aseptic group. When the postoperative scores were compared, a significant difference was found in the two groups ($P < 0.05$), the aseptic group still had a better knee function restoration.

Table 3: Comparison of joint line and patellar height between the two groups

	JL				
	Pre-TKA	**Post revision**	**95% CI**	**Changes**	***P***
Septic group	17.47±2.62	17.02±5.35	15.44-18.59	−0.46±5.47	0.566
Aseptic group	17.56±6.60	20.74±7.06#	17.94-23.53	3.17±8.88	0.074
P	0.938	0.013*		0.032*	
	PT length				
	Pre-TKA	**Post revision**	**95% CI**	**Changes**	***P***
Septic group	42.96±3.92	38.52±9.32	35.78-41.25	−4.45±10.54	0.006#
Aseptic group	42.85±3.96	41.09±8.34	37.79-44.39	−1.76±9.40	0.340
P	0.903	0.239		0.276	
	IS ratio				
	Pre-TKA	**Post revision**	**95% CI**	**Changes**	***P***
Septic group	0.99±0.11	0.89±0.23	0.82-0.96	−0.10±0.22	0.003#
Aseptic group	0.96±0.15	0.97±0.23	0.88-1.05	0.01±0.18	0.811
P	0.351	0.169		0.035*	
	Patellar baja				
	Pre revision	**Post revision**	**95% CI**	**Changes**	***P***
Septic group	15	9	0.342-2.569	−6	0.900
Aseptic group	6	3	0.268-5.12	−3	0.834
P	0.373	0.367		0.834	

*Means compare between septic and aseptic groups; #Means compare between pre-TKA and post revision TKA. JL=Joint line, IS=Insall-Salvati, CI: Confidence interval, TKA=Total knee arthroplasty, PT=Patellar tendon

Table 4: Comparison of clinical results between the two groups

	Pre revision	**Last followup**	**95% CI**	***P***
HSS				
Septic group	41.26±12.07	71.74±15.82	67.10-76.39	0.000#
Aseptic group	51.56±11.32 (0.001*)	82.00±13.71 (0.006*)	76.58-87.42	0.000#
Total	45.01±12.74	75.49±15.79	71.83-79.14	0.000#
KSS				
Septic group	65.32±17.74	124.30±17.28	119.23-129.37	0.000#
Aseptic group	98.06±16.86 (0.000*)	143.37±15.52 (0.001*)	132.23-144.51	0.000#
Total	77.27±18.72	129.43±17.90	125.29-133.58	0.000#
WOMAC				
Septic group	61.59±8.23	38.71±16.19	33.95-43.46	0.000#
Aseptic group	60.26±11.08 (0.587)	24.50±15.30 (0.019*)	23.45-35.55	0.000#
Total	60.74±16.38	35.35±16.38	31.55-39.14	0.000#
ROM				
Septic group	54.96±40.78	95.43±26.06	87.77-103.08	0.000#
Aseptic group	106.11±17.83 (0.000*)	119.12±15.61 (0.000*)	113.08-125.43	0.014#
Total	73.62±42.14	104.12±25.46	98.22-110.02	0.000#

*Means significant difference between septic and aseptic groups, #Means significant difference between pre revision and last followup. CI=Confidence interval, ROM=Range of motion, KSS=Knee Society Score, WOMAC=Western Ontario and McMaster Universities, HSS=Hospital for special surgery

According to all the revision knees, the JL position post revision had a positive correlation to the IS ratio ($P = 0.023$, $r = 0.264$) and PT length post revision ($P = 0.046$, $r = 0.233$), and IS ratio post revision had a significant correlation to the PT changes ($r = 0.923$, $P = 0.000$). The JL changes had no correlation to the IS ratio changes ($r = 0.214$, $P = 0.067$) and no correlation to the PT length changes ($r = 0.217$, $P = 0.064$). To all the revision knees, the JL position and IS ratio post revision had no significant correlation to the HSS, KSS, WOMAC scores and ROM ($P > 0.05$). At the same time, the JL changes and IS ratio changes also had no correlation to the changes of HSS, KSS, WOMAC scores, and ROM ($P > 0.05$).

Complications

Different complications occurred in 14 knees post revision. In septic revision group (9 knees), 3 knees suffered reinfection and underwent re-revision. Four knees had a patellar subluxation. One knee suffered serious patellar baja (IS: 2.0) and flexion contracture. One knee had a patellar fracture. In the aseptic group (5 knees), 1 knee had deep infection post revision, 2 knees had supracondylar fracture and underwent internal fixation. Two knees had patellar tilt and anterior knee pain caused by lateral impingement. The complication ratio had no significant difference between the two groups ($P = 0.947$).

Discussion

The most important findings of this study were the JL position sufficiently restored to the preprimary TKA level with appropriate distal femoral augment reconstruction in revision TKA; this proved our first hypothesis. However, the IS ratio significantly declined and patellar baja could not be improved after revision TKA. The JL changes had no correlation to the IS ratio changes, this was converse to our second hypothesis. The knee function restored better in the aseptic group than the septic group, but no correlation was found between the JL position and patellar height to the improvement of knee function post revision TKA, this was conflict to our third and fourth hypothesis.

In revision TKA, there is a tendency to proximalise the JL due to three main reasons: First is the always inevitable distal femoral bone loss as a result of osteolysis, infection, migration of the component, or damage to the distal femur during removal of the component.[19] Second, the surgeons have the subjective tendency to undersize the femoral component to fit the remnant smaller distal femur. The third is the relatively larger flexion space compared to the extension space,[20] when the bone lost from the posterior femur is not reconstructed and the defect is addressed by thickening the tibial insert.

Before the development of modern knee revision systems, the presence of femoral bone loss often required elevation of the JL to obtain stable fixation of the femoral component. Now the commercially knee revision systems provide selective augments to reconstruct bone deficiencies encounter in revision.[11]

However, some reports showed the JL cannot be restored accurately even with the augmented reconstruction. Partington *et al*. observed that 79% of JL positions were elevated by more than 8 mm (from 16 mm before TKA to 24 mm post revision) and he concluded that the use of thicker augments would improve the height of the JL.[1] Porteous *et al*.[19] reported JL elevated (5 mm above the preoperative height) in 36% of their revision TKAs. Azzam *et al*.[2] reported the JL elevated 7.42 ± 4.96 mm in the unstable group and 3.69 ± 4.75 mm in the stable group. In the stable group, 15.63% patients had a JL decline, and the augment application ratio was 50% in femur and 14% in tibia side. Laskin[12] proved more than 1/2 of their revision patients (45 knees instability, 44 cases) had a proximally malpositioned JL. Mahoney and Kinsey[11] reported the JL position was raised in seven knees and lowered in 15, restored to within ± 2 mm of anatomic position in 12 of the 22 knees, the mean JL position change from the anatomic position was 1.6 ± 2.3 mm decline.

Therefore, the failure of JL restoration has led to the recommendation that distal femoral augments should be used more frequently and in greater thickness in revision TKA.[21] In our study, the JL position sufficiently restored to the preprimary TKA level. In septic group, the JL declined from 17.47 mm to 17.02 mm, with (80.85%, 38/47) knees performed distal femoral augment reconstruction (medial average 6.38 mm, lateral average 6.60 mm). The decline of JL was derived from the use of thicker augments. But in the aseptic group, the distal femoral bone deficiency was minor; only 14 knees (51.85%) underwent augment reconstruction with the mean thickness <3.20 mm. Moreover, the JL elevated 3.17 mm from 17.56 mm preoperative to 20.74 mm post revision. Fourteen knees (6 knees in septic group and 8 knees in the aseptic group) had a JL elevation ≥5 mm, the total ratio was 18.92% (14/74), and it was lower than the ratio of 36% reported by Porteous *et al*.[19]

Another complex and difficult procedure in revision TKA is the restoration of the patellar height. Khakharia *et al*.[16] reported 76 cases of revision TKA (septic 12 knees and aseptic 64 knees), the overall IS ratio increased from 1.02 to 1.04, the IS ratio of septic group declined from 1.07 to 0.99, and the aseptic group increased from 1.01 to 1.05. Nine patients had preoperative patella baja (septic 2 knees

and aseptic 7 knees), and 7 of these had an improvement to normal height, but no statistical difference was found due to the baja changes post revision. However, our study indicated the IS ratio declined from 0.98 to 0.92, this can be explained by the more septic revision knees in our study, which had a decline of JL from 0.99 to 0.89. Second, in Khakharia's study the IS ratio was calculated by the length of the patellar ligament and the longest dimension of the patellar surface, which can increase the value of IS ratio obviously. In our study, only 9 knees from the 21 patella baja knees (septic 15 knees and aseptic 6 knees) pre revision improved to normal patellar height, the unsatisfied results compared to Khakharia also is derived from the more septic revisions in our study. Overall, both studies proved that the patellar baja cannot be well improved after revision, even with surgical reconstruction of the patellar height by quadricepsplasty, TTO, or the distal migration of the JL. As literature reported,[22,23] the unsatisfied restoration of patellar height is caused by the scarring or contracture of the PT. Our study indicated the IS ratio post revision had a significant correlation to the PT changes of preprimary and post revision TKA.

Several studies have shown restoration of JL gives rise to better clinical and functional outcomes in revision TKA.[1,12,20,19] Porteous *et al*.[19] reported restoration of the JL gives a significantly better result than leaving it unrestored by more than 5 mm. Figgie *et al*.[17] have shown that elevation of the JL by more than 8 mm at primary TKR is associated with an inferior clinical result. Hofmann *et al*.[24] found there was a significant improvement with a recreation of the normal JL to within ±4 mm for KSS score, ROM when combined outliers were compared with goal range (−4–4 mm).

In this study, we found knee function improved significantly after revision surgery in both septic and aseptic groups, and the septic revision had a lower function restoration compared to the aseptic group, this was similar to literature reported.[2,22,25,26] However, we found no correlation of JL, patellar height post revision, or their changes to the clinical values or their changes, including the HSS, KSS, WOMAC scores, and ROM, even with significantly improvement post revision TKA surgery. This may be due to the small sample size, but we considered the main reason for knee function recovery post revision was the primary knee pathological changes control, such as the infection cure in septic revision, knee stability, and good knee kinematic restoration postaseptic revision.

The limitations of this study were that it's retrospective study; the sample size for this study is insufficient especially in the aseptic revision group, the followup is short and the coronal, rotational alignment of the operated knee was not analyzed. The patellar Merchant view was not evaluated due to the difficulty to obtain the satisfied patellar Merchant view post revision. All these factors can affect the knee function post revision. Lastly, because of the osteophyte formation in the patellar articular surface with uncontrolled patellar resurfacing or not postprimary TKA, the Blackburne-Peel ratio that can directly reflects the patellar height referred to the JL cannot be performed and evaluated in this study.

Conclusion

The JL position can be sufficiently restored with appropriate distal femoral augment reconstruction in revision TKA, but the patellar height cannot be well improved, especially in the septic revision with obviously PT contracture. Clinically, we should invent some new methods to prevent the PT contracture in cement spacer period and to improve the patellar height by PT elongation in the revision surgery, not only paid much more attention to the JL restoration, even the direct correlation of patellar height to the knee function post revision was not found in this study.

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Conflicts of interest
There are no conflicts of interest.

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