Restoration of the Distal Femur Impacts Patellar Height in Revision TKA

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Abstract

Background Restoring patellar height is important in revision TKA for normal knee function and kinematics. Alteration in patellar height after revision TKA is associated with inferior extensor mechanism function.

Questions/purposes We determined whether gap balancing with bone preservation and distal femoral augmentation would restore patellar height and patellar height changed in patients undergoing septic and aseptic revision TKA.

Patients and Methods We retrospectively reviewed 76 patients who had revision TKA between 2006 and 2009; 12 had two-stage revisions for infected TKA, and 64 had revision for aseptic failure. We compared preoperative and postoperative radiographs and measured the patellar height using the Insall-Salvati ratio in both groups. We reviewed operative records to determine type of exposure and amount of distal femoral augmentation used to restore the joint line.

Results Overall mean preoperative and postoperative Insall-Salvati ratios were 1.02 and 1.04, respectively. In the septic group, mean preoperative and postoperative Insall-Salvati ratios were 1.07 and 0.99, respectively. In the aseptic group, mean preoperative and postoperative Insall-Salvati ratios were 1.01 and 1.05, respectively. Overall, nine patients had preoperative patella baja; seven of these

had an improvement to normal height. There was little difference in preoperative and postoperative Insall-Salvati ratios in patients with patella alta. Distal augmentation was used in 10 of 12 patients in the septic group and 48 of 64 patients in the aseptic group.

Conclusions Surgeons can maintain normal patellar height and improve patella baja by preserving bone stock and using distal femoral augments to restore the distal joint line during revision TKA.

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

Introduction

Over the years, there has been a steady increase in the number of revision TKAs (RTKAs) for a multitude of reasons, including aseptic and septic causes [2, 9, 13]. These are complex procedures that rely on the restoration of the joint line position and normal patellar height for normal knee function and kinematics. Lowering of the joint line may be associated with anterior knee pain and high risk of patellar subluxation [6, 10]. Elevation of the joint line and patella baja can cause patella impingement, polyethylene wear, flexion limitation, and anterior knee pain [1, 3, 11, 21, 23].

Several studies show restoration of the joint line gives rise to better knee and functional scores after RTKA [1, 4, 12, 15–17]. Therefore, it is critical to restore the joint line and patellar height during RTKA.

We determined the difference between preoperative and postoperative patellar height (1) after RTKA, (2) after two-stage RTKA for septic reasons, and (3) after single-stage RTKA for aseptic reasons; and (4) the impact of bone

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preservation and distal femoral augmentation on joint line and patellar height during RTKA with a gap-balancing technique.

Patients and Methods

We retrospectively reviewed the radiographs of all 102 RTKAs (102 patients) performed by the senior author (GRS) between 2006 and 2009. Of the 102 patients, 26 were lost to followup or had inadequate radiographs, leaving 76 patients for inclusion in the study. There were 48 women and 28 men with a mean age of 66 years (range, 46–89 years). Twelve patients underwent two-stage revision with a static spacer for infection while 64 had single-stage revision for aseptic reasons (Table 1). We did not recall any patients for this study; we obtained all data from medical records and radiographs, which were taken at 6 weeks' followup. The surgical technique for RTKA was similar for all patients and performed by the senior surgeon. The surgeon exposed the knee using a medial parapatellar arthrotomy, quadriceps snip, quadriceps turn-down, or tibial tubercle osteotomy (Table 2). The operative technique attempted to preserve bone during implant removal since the residual bone was the foundation for the reconstruction, followed by flexion and extension gap balancing. A modern modular revision total knee implant, which allowed modular augmentation of the distal and posterior femoral component in 5-mm increments, was used in all cases. The intention during RTKA was to

balance the flexion and extension gaps with an appropriately sized femoral component set at the appropriate distance to re-establish the joint line. After knee exposure and careful removal of the previous implant, the surgeon performed the tibia reconstruction, followed by the sizing of the femur and re-establishment of the flexion gap. Once they selected the appropriately sized femoral component, they measured the distance to the distal joint line from the medial and lateral epicondyles. The surgeon added distal augmentation to the femoral component to establish the distal joint line and balance the extension gap. The planned distance from the medial and lateral epicondyles was 25 to 30 mm. The surgeon also identified the meniscal scar and used it as a secondary landmark for determining the joint line. The meniscal scar was the remnant of the meniscus rim after primary TKA, which helped in determining the original joint line of the knee (Fig. 1).

We reviewed the operative records for all cases to determine the amount of distal femoral augmentation needed to restore the distal joint line. Forty-eight of the 64 patients in the aseptic group (75%) and 10 of the 12 patients in the septic group (83%) underwent distal augmentation. While modular augmentation was available in 5-mm increments, the mean distal augmentation in the aseptic group was 4.4 mm (range, 0–20 mm) on the medial femoral condyle and 4.68 mm (range, 0–20 mm) on the lateral condyle; the mean distal augmentation in the septic group was 6.25 mm (range, 0–20 mm) on the medial femoral condyle and 6.66 mm (range, 5–20 mm) on the lateral condyle.

An orthopaedic surgeon (SK), who was not involved in the surgery, measured the preoperative and postoperative

Table 1. Distribution of entire cohort of revision TKA based on mechanism of failure

Mechanism of failure	Number of knees (n = 76)
Arthrofibrosis	16
Loosening	24
Instability	22
Loosening and instability	2
Infection	12

Table 2. Distribution of type of exposure used during revision TKA

Approach/exposure	Number of knees	
	Septic (n = 12)	Aseptic (n = 64)
Medial parapatellar approach	8	58
Quadriceps snip	2	4
Quadriceps turn-down	1	1
Tibial tubercle osteotomy	1	1

Fig. 1 An intraoperative photograph shows the meniscal scar.

patellar height on lateral radiographs by using the Insall-Salvati (IS) ratio [7], which calculated the ratio between the length of the patellar ligament and the longest dimension of the patellar surface (Fig. 2). The average normal value of the ratio is 1.02 (range, 0.80–1.20). We defined patella baja as a ratio of less than 0.80 and patella alta as a ratio of more than 1.20 [7, 20].

The cohort was stratified based on preoperative patellar height (IS ratio) into patella alta, patella baja, and normal patellar height. We determined differences in preoperative and postoperative IS ratios for each patient within each of the three stratified subgroups (patients with patella baja, normal IS ratio, and patella alta) using the paired t test. We calculated the mean and SDs of the preoperative and postoperative IS ratios within each group and determined the differences between the mean preoperative and postoperative IS ratios within each group using the paired t test. The software used was GraphPad[®] (GraphPad Software Inc, La Jolla, CA).

Results

For all 76 patients, the mean preoperative IS ratio was 1.02 (range, 0.67–1.56) and the mean postoperative IS ratio was 1.04 (range, 0.72–1.65) (Table 3). Specifically looking at patella baja, seven of nine patients had an improvement to

a normal height. The preoperative and postoperative IS ratios were similar within the patella alta group ($p = 0.30$) and within the normal IS ratio group ($p = 0.25$) but different within the patella baja group ($p = 0.01$).

For the septic group, the mean preoperative IS ratio was 1.07 (range, 0.75–1.36) and the mean postoperative IS ratio was 0.99 (range, 0.83–1.23) (Table 4). There were two patients with patella baja in the septic group and both showed improvement in the IS ratio. When looking at the three patients with patella alta, only one had restoration to a normal IS ratio postoperatively (0.96), while the other two remained patella alta by a very slight margin (1.23 and 1.22, respectively).

For the aseptic group, the mean preoperative IS ratio was 1.01 (range, 0.67–1.56) and the mean postoperative IS ratio was 1.05 (range, 0.72–1.65) (Table 5). Postoperatively, five of the seven knees (71%) with preoperative patella baja improved to a normal height.

We recorded the details of the number of patients in the septic group who received distal augments with their

Fig. 2A–B A radiograph demonstrates the IS ratio, ie, the ratio between the length of the patellar ligament (A) and the longest dimension of the patellar surface (B).

Table 3. Distribution of preoperative and postoperative patellar height for entire study cohort

Height	Preoperative (n = 76 knees)	Postoperative (n = 76 knees)
Normal height (number of knees)	55 (72.4%)	60 (78.9%)
Insall-Salvati ratio*	1.00 (0.81–1.20)	0.99 (0.83–1.20)
Patella alta (number of knees)	12 (15.8%)	14 (18.4%)
Insall-Salvati ratio*	1.31 (1.21–1.56)	1.31 (1.21–1.65)
Patella baja (number of knees)	9 (11.8%)	2 (2.7%)
Insall-Salvati ratio*	0.74 (0.67–0.79)	0.72 (0.72–0.73)

* Values are expressed as mean, with range in parentheses.

Table 4. Distribution of preoperative and postoperative patellar height for the septic group

Height	Preoperative (n = 12 knees)	Postoperative (n = 12 knees)
Normal height (number of knees)	7 (58.3%)	10 (83.3%)
Insall-Salvati ratio*	1.07 (0.97–1.16)	0.94 (0.83–1.14)
Patella alta (number of knees)	3 (25 %)	2 (16.7%)
Insall-Salvati ratio*	1.29 (1.21–1.36)	1.22 (1.22–1.23)
Patella baja (number of knees)	2 (16.7%)	0
Insall-Salvati ratio*	0.77 (0.75–0.79)	

* Values are expressed as mean, with range in parentheses.

Table 5. Distribution of preoperative and postoperative patellar height for the aseptic group

Height	Preoperative (n = 64 knees)	Postoperative (n = 64 knees)
Normal height (number of knees)	48 (75%)	50 (78.1%)
Insall-Salvati ratio*	0.99 (0.81–1.20)	1.00 (0.84–1.20)
Patella alta (number of knees)	9 (14.1%)	12 (18.8%)
Insall-Salvati ratio*	1.32 (1.21–1.56)	1.32 (1.21–1.65)
Patella baja (number of knees)	7 (10.9%)	2 (3.1%)
Insall-Salvati ratio*	0.73 (0.67–0.79)	0.72 (0.72–0.72)

* Values are expressed as mean, with range in parentheses.

Table 6. Number of knees receiving distal augments in the septic group

Height	Preoperative (n = 10 knees)	Postoperative (n = 10 knees)
Normal height (number of knees)	6	8
Insall-Salvati ratio*	1.07 (0.97–1.16)	0.96 (0.85–1.14)
Patella alta (number of knees)	3	2
Insall-Salvati ratio*	1.29 (1.21–1.36)	1.22 (1.22–1.23)
Patella baja (number of knees)	1	0
Insall-Salvati ratio*	0.75	

* Values are expressed as mean, with range in parentheses.

preoperative and postoperative patellar height (Table 6). Ten patients in this group received distal augmentation while two patients did not require augmentation. We also recorded the details of the number of patients in the aseptic group who received (Table 7) and did not receive (Table 8) distal augments with their preoperative and postoperative patellar height. In this group, 48 of 64 (75%) received distal augments. Of these 48 patients, five had patella alta preoperatively, and the use of distal augmentation increased the number of knees with patella alta to eight. With the use of distal augmentation, one of two patients with patella baja in the septic group and three of five patients with patella baja in the aseptic group improved to normal IS ratio. Preservation of distal femoral bone and distal femoral augmentation also impacted joint line position, as determined by the distance from the epicondyles and the meniscal scar.

Discussion

The literature suggests TKA may be associated with a high incidence of patellar tendon shortening and resultant

Table 7. Number of knees receiving distal augments in the aseptic group

Height	Preoperative (n = 48 knees)	Postoperative (n = 48 knees)
Normal height (number of knees)	38	38
Insall-Salvati ratio*	0.99 (0.81–1.20)	1.00 (0.84–1.20)
Patella alta (number of knees)	5	8
Insall-Salvati ratio*	1.27 (1.22–1.33)	1.28 (1.23–1.36)
Patella baja (number of knees)	5	2
Insall-Salvati ratio*	0.72 (0.67–0.79)	0.72 (0.72–0.725)

* Values are expressed as mean, with range in parentheses.

Table 8. Number of knees not receiving distal augments in the aseptic group

Height	Preoperative (n = 16 knees)	Postoperative (n = 16 knees)
Normal height (number of knees)	10	12
Insall-Salvati ratio*	0.99 (0.80–1.14)	1.03 (0.86–1.13)
Patella alta (number of knees)	4	4
Insall-Salvati ratio*	1.37 (1.21–1.56)	1.41 (1.21–1.65)
Patella baja (number of knees)	2	0
Insall-Salvati ratio*	0.74 (0.69–0.79)	

* Values are expressed as mean, with range in parentheses.

patella baja [4, 8, 15]. RTKA is challenging and a complex procedure compared to primary TKA. Several studies show restoration of joint line gives rise to better clinical and functional outcomes in RTKA [12, 16, 17]. Therefore, restoration of patellar height and joint line is of vital importance to achieve better clinical and functional outcomes in RTKA. We determined the difference between preoperative and postoperative patellar height (1) after RTKA, (2) after two-stage RTKA for septic reasons, and (3) after single-stage RTKA for aseptic reasons; and (4) the impact of bone preservation and distal femoral augmentation on joint line and patellar height during RTKA with a gap-balancing technique.

Our study had a number of limitations. First, this was a retrospective chart and radiographic review, but the degree of bone loss and femoral augmentation was reported in the operative report, and the radiographs of the available cohort were appropriately positioned lateral views allowing accurate measurement of patellar height. Second, this was an observational study on patellar height and did not report

on the functional outcome of the cohort of patients. However, prior studies have reported the impact of patellar height on functional outcome, and our intention was to report our clinical observation on patellar height after our preferred surgical technique. Third, the majority of patients were either of normal patellar height or patella baja, so it was difficult to draw conclusions from the patients with patella alta, yet their IS ratios were close to normal.

We noted an overall difference in the patellar height after RTKA. After a gap-balancing technique with preservation of the distal femoral bone and/or modular augmentation, normal patellar height and the femoral-tibial joint line were maintained and patella baja improved. Looking further into the mechanism of failure and reason for RTKA, it was apparent there was more bone loss in the septic cases, and greater distal femoral augmentation was needed to restore patellar height. The impact of component removal and débridement on bone loss in RTKA for sepsis is well documented [14, 18], with a direct impact on patellar height.

In the nine patients with patella baja, seven were corrected to a normal patellar height, and distal augments were successful in one of two patients in the septic group and three of five patients in the aseptic group. It is also apparent bone stock preservation has a considerable effect on patellar height and joint line restoration since one of two patients in the septic group and two of five patients in the aseptic group improved. Hsu et al. [5] reported a 10% incidence of patella baja in RTKA. However, their study did not report the cause for patella baja or the surgical technique for restoring patellar height to normal. Our study tried to address this limitation and reported on the treatment options for restoring joint line position and patellar height in RTKA, reinforcing well-established surgical principles for RTKA [14, 18, 19, 22]. The three-step technique, recommended by the senior author (GRS), included first re-establishing the tibial surface, followed by selecting the appropriately sized femoral component, establishing the flexion gap, and setting the femoral component, establishing the extension gap [14, 18, 19]. It was this latter step that impacted the patellar height and distal joint line. The epicondyles were readily identifiable and reliable reference points, with an average distance from the lateral and medial epicondyles to the joint line of approximately 23 and 28 mm, respectively (Fig. 3). Additionally, at the time of surgery, the surgeon could determine the joint line position by location of the meniscal scar (Fig. 1). Modularity in RTKA allowed selective augmentation to deal with deficiencies on the distal and posterior femur (Fig. 4). The ability to selectively augment the femur was helpful in balancing the soft tissues, providing ligament stability, and restoring the joint line impacting patellar height.

Fig. 3 A photograph shows the distance of the medial and lateral epicondyles to the distal joint line.

Fig. 4 A photograph shows how the modular augmentation of the distal femur establishes the joint line.

In conclusion, during an RTKA using the gap-balancing technique, bone preservation is critical, modular augmentation allows for intraoperative adjustments when bone loss is present, and the combination of these factors influences the patellar height and joint line position.

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