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Outcomes of the Rotating Hinge Knee in Revision Total Knee Arthroplasty: A Short-term Report with a Median Follow-up of 2.75 Years in a Large Asian Institute

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Purpose: Revision total knee arthroplasty (TKA) is often necessary because of infection and malalignment and represents significantly greater challenges. Rotating-hinge knee (RHK) play an important role in complex situations, with survival rates varying from 73% to 97.2% over 5 to 10 years. However, most knee arthroplasty concepts are primarily tailored to suit Caucasians, potentially raising concerns about their suitability for Asian populations. The purpose of our research was to determine the rates of survival and complications, as well as to review the factors that contribute to failed RHK revisions in our large Asian institute.

Methods: This retrospective study included all revisions with RHKs performed between January 2013 and December 2021 while excluding those who underwent primary RHK procedures. Data collection included revision diagnoses and reasons for RHK implant failure. Implant survivorship was calculated from the date of surgery to the time of re-revision surgery.

Results: This study included 37 patients, consisting of four men and 33 women participants, with an average age of 75 years. The mean follow-up was 2.75 years. The main causes of revision to RHK were prosthetic joint infection and instability, both accounting for 29.7% of cases, followed by aseptic loosening at 21.6%. The 2-year survival rate was 91.67%. The mean survival time was 2.08 years, with an overall failure rate of 5.4% due to infection.

Conclusions: RHK implants are essential in revision knee arthroplasty under specific conditions. Our large Asian institution has shown a 2-year survival rate of 91.67% and a recurrence-free survival rate of 94.6%.

Keywords: Rotating hinge knee, Revision knee arthroplasty, Survival rate, Complication

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Revision total knee arthroplasty (TKA) is typically required after failure of primary TKA due to prosthetic joint infection (PJI), periprosthetic fracture, aseptic loosening, polyethylene wear, and instability [(1)]. Although a CR or PS prosthesis can resolve most causes for revision, in complex cases involving collateral ligament insufficiency, severe varus or valgus deformity (>20°) accompanied by

significant soft-tissue release and bone loss, compromised collateral ligament insertions, gross flexion-extension gap imbalance, ankylosis, and hyperlaxity [2], the rotating-hinge knee (RHK) is the only remaining implant option.

Survival rates for RHK, as reported in several studies [3-6], range from 73% to 84.5% for 5-year survival and from 51% to 97.2% for 10-year survival. The potential causes of RHK implant failure include infection, instability, aseptic loosening, arthrofibrosis, and periprosthetic fractures.

Notably, most TKA prostheses are based on the typical characteristics of Caucasian populations [7]. Due to distinct anatomical features, such as a higher degree of tibial torsion and lesser varus knee in the Japanese population, a mismatch in the femoral aspect ratio (mediolateral/anteroposterior), and the requirement for greater degrees of motion for traditional activities compared to that in Caucasians [2], reports [8] suggest potential incompatibilities for Asian populations.

The main objectives of our study were to evaluate the survival rates of RHK implants, analyze the complication rates within our large high-standard Asian institution, and investigate the reasons for implant failure.

MATERIALS AND METHODS

A retrospective analysis was conducted using data from our institute between January 1, 2013, and December 31, 2021, and was approved by the Institutional Review Board. This study included patients who underwent revision knee arthroplasty using RHK. The indications for RHK revision included severe instability, significant bone loss, infection, aseptic loosening, and periprosthetic fractures. Patients who underwent RHK as primary surgery and those with incomplete data were excluded. The specific models of RHK used in this study were the S-ROM™ NOILES™ Rotating Hinge Knee System (DePuy Synthes) and the NexGen® Rotating Hinge Knee (Zimmer Biomet). We gathered data on patient demographics, diagnoses at the time of revision, revision dates, and causes of RHK implant failure. Failures were categorized into several types, including infection, aseptic loosening, periprosthetic fracture, instability, recurrent dislocation, and malalignment.

Implant survival was determined from the date of surgery, with the endpoint defined as the time at which revision surgery was required. This included exchanging modular components or partial or full implant removal. The reasons for these deviations were collected and categorized in a manner similar to the causes of the initial failure.

Statistical Analysis

Continuous data were represented as either mean ± SD or median (interquartile range) based on the data distribution. Categorical data were expressed as numbers and percentages. The Kaplan–Meier method was used to estimate implant survival. Logistic regression was used to explore the factors related to RHK implant failure. Statistical significance was set at $p < 0.05$.

RESULTS

This study included 37 patients who received RHK implants, consisting of four men (10.8%) and 33 women (89.2%). The mean patient age was 75 years (65.5–78). The mean body mass index (BMI) was 24.8 kg/m^2 (23.1–27.6). The most prevalent underlying conditions were diabetes mellitus (70.3%), hypertension (64.9%), and dyslipidemia (27%). The mean follow-up period was 2.75 years, with the longest follow-up being 8.73 years. The patient characteristics are shown in Table 1.

The most common reasons for RHK revision were PJI and instability, each occurring in 11 knees (29.7%), followed by aseptic loosening in eight knees (21.6%). Figure 1 illustrates the causes of RHK revision.

Survival Rate

Kaplan–Meier analysis revealed that the mean survival time in our study was 2.08 years, with a 95% confidence interval (CI) of 0.60 to 3.56 years. According to the Kaplan–Meier analysis, the revision-free rate was 94.6%. The overall failure rate of RHK was 5.4% (two RHKs), with all failures attributed to infection. All the patients who underwent re-revision were women. The first case involved a 64-year-old woman with diabetes mellitus, hypertension, and dyslipidemia who

underwent revision RHK for PJI. Two years after the revision surgery, she developed pain, and the sinus tract of the affected knee was diagnosed with chronic PJI. She underwent debridement and prosthesis removal. The second case involved an 85-year-old woman with diabetes mellitus and dyslipidemia who underwent revision RHK for a periprosthetic fracture. Three months after the revision surgery, the patient developed pain and swelling of the knee, was diagnosed with acute PJI, and underwent debridement and modular part exchange. In our study, the 2-year survival rate of patients with RHK was 91.67% as shown in *Fig. 2*.

Table 1 Demographic data.

Characteristics[1]	**RHK patients (n=37)**
Age	75 years (65.5 – 78)
Height	151.3 cm (144.85 – 156.45)
Weight	56.8 kgs (51.85 – 62.55)
BMI[2]	24.8 kg/m^2 (23.05 – 27.55)
Gender	
Female	33 patients (89.2%)
Male	4 (10.8%)
Side	
Rt	21 (56.8%)
Lt	16 (43.2)
UD	
DM[3]	26 (70.3%)
HT[4]	24 (64.9%)
DLP	10 (27%)
None	9 (24.3%)
Cause of Failure	
Aseptic Loosening	8 (21.6%)
Instability	11 (29.7%)
Mal Alignment	1 (2.7%)
Periprosthetic Fracture	5 (13.5%)
PJI[5]	11 (29.7%)
Recurrent Dislocation	1 (2.7%)
Re-revision	2 (5.4%)
Cause of Failure	
Infection	2 (100%)
Implant	
Exchange Liner	1 (50%)
Remove implant	1 (50%)

[1]Characteristics: Mean (range) values are presented for age, height, weight, and BMI, [2]BMI: Body Mass Index, [3]DM: Diabetes Mellitus, [4]HT: Hypertension, [5]PJI: Prosthetic Joint Infection

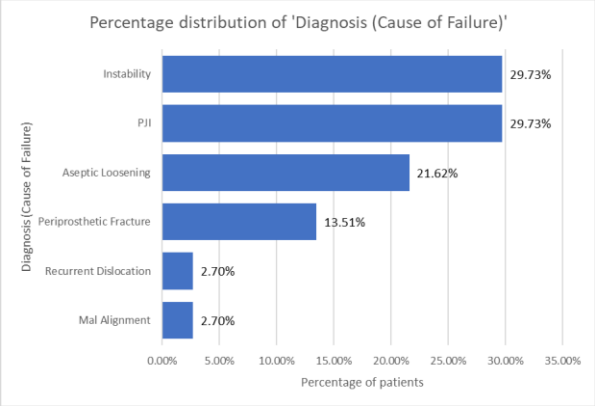

Fig. 1 Causes of failure. PJI, prosthetic joint infection.

(This figure illustrates the distribution of various causes of failure for RHK revisions in our study cohort. Each category is presented as a percentage of the total failures observed in the study. This detailed breakdown helps to identify the most common reasons for RHK failure, informing clinical practices and potential areas for improvement in surgical techniques and postoperative care.)

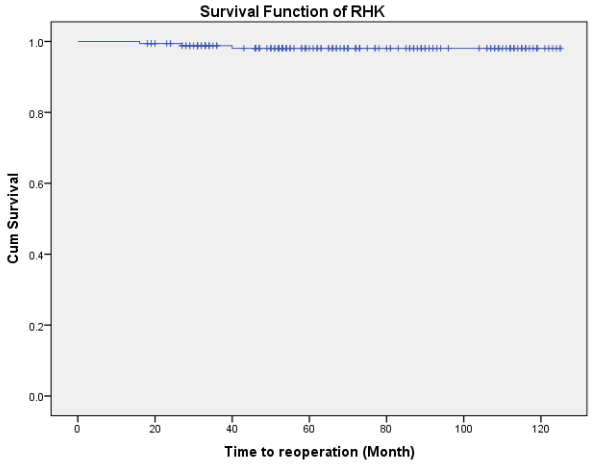

Fig. 2 Survival rate.

(This figure presents the Kaplan-Meier survival curve for RHK implants over a follow-up period. The survival rate is defined as the percentage of implants that have not required re-revision surgery over time. The curve illustrates the durability and performance of RHK implants in our study cohort, providing insights into their long-term efficacy.)

Factors Influencing RHK Implant Failure

We performed both univariate and multivariate analyses to identify factors associated with RHK implant failure. The results are summarized in Table 2. Univariate analysis showed that age had an odds ratio (OR) of 1.016 (95% CI, 0.867–1.191; p = 0.841), and BMI had an OR of 1.279 (95% CI, 0.906–1.805; p = 0.162). In the multivariate analysis, age showed an OR of 1.011 (95% CI, 0.865–1.183; p = 0.890), and BMI showed an OR of 0.276 (95% CI, 0.904–1.802; p = 0.165).

DISCUSSION

RHK arthroplasty uses a highly constrained prosthesis in complex knee arthroplasty. The average age of the patients at the time of revision in our study was 75 years (65.5–78), which is in line with Gilles et al.'s systematic review [9], which reported a mean age range of 60 to 79 years across various studies. Our study found that the most common causes of RHK were infection (29.73%), instability (29.73%), and aseptic loosening (21.62%). These findings align with Shalen et al.'s systematic review [10], which identified infection (43%), instability (24%–30%), and aseptic loosening (45%–60%) as the primary indications for revision with RHK.

In our study, neither age nor BMI were statistically significant predictors of RHK implant failure. Univariate analysis showed no significant association between age and BMI. Multivariate analysis confirmed these findings, with age (OR 1.011; 95% CI, 0.865–1.183; p = 0.890) and BMI (OR 0.276; 95% CI, 0.904–1.802; p = 0.165) remaining non-significant, indicating that other factors may influence implant survival apart from age and BMI.

To the best of our knowledge, this is one of the few Asian studies on revision knee arthroplasty using RHK implants. The study showed a 2-year survival rate of 91.67%, which was the highest among previous Asian studies, as demonstrated in Table 3 [11, 12], and was comparable to the findings of Cottino et al.'s report [3], which revealed survival rates of 84.5% after 5 years and 71.3% at 10 years. Similar to the report by Giurea et al. [5], the 2-year survival rate was 85.4%. Conversely, Farid et al. [4]

observed a decrease in survival rates, with 73% at 5 years and 51% at 10 years, potentially due to their higher infection rates, which were 43% compared to our rates of 29.73%. A point of concern in these comparisons was the follow-up period, which varied among the studies.

The main limitations of our study were its small sample size, retrospective cohort study design, incomplete data, and relatively short follow-up duration. Future studies should include larger patient cohorts with longer follow-up periods.

Table 2 Univariate and Multivariate Analysis of Factors Associated with RHK Implant Failure. CI, confidence interval.

Factors	Univariate			Multivariate		
	Odds ratio	95% CI	p-value	Odds ratio	95% CI	p-value
Age	1.016	0.867 – 1.191	0.841	1.011	0.865 – 1.183	0.890
Body mass index (kg/m^2)	1.279	0.906 – 1.805	0.162	0.276	0.904 – 1.802	0.165

Table 3 Survival rate of Revision RHK in Asian studies.

Author (year of publication)	No. of Knees	Duration of follow up (years)	Overall Revisions (Rate)	Revisions for Aseptic Loosening (Rate)	Revisions for Infection (Rate)	Complications (rate)	All-Cause Survivorship (Rate)
Rajgopal (2020)	117	10.3	10.2%	5.12%	5.12%	12.82%	10 years survival rate 90.65%
Hwang SC (2010)	13	2.4	38.5%	-	15.4%	38.5%	61.5%
Current study	37	2.8	5.4%	-	5.4%	5.4%	2-year survival rate 91.67%.

CONCLUSIONS

RHK implants are essential for managing complex revision knee arthroplasties. In our study, we observed a 91.67% 2-year survival rate and a 94.6% re-revision-free survival rate. Logistic regression analysis revealed that the patient characteristics were not significantly associated with the risk of RHK failure. The primary indications for RHK revision are PJI and instability. These results suggest that RHK implants effectively provide stability and control infections in cases of revision TKA.

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