Journal of Southeast Asian Orthopaedics
ISSN 2821-9848 (Print)
ISSN 2821-9864 (Online)
https://doi.org/10.56929/jseaortho-023-0176 https://jseaortho.org

Short-Term Global Instability and Genu Recurvatum Outcomes of Revision Total Knee Arthroplasty with Rotating-Hinged Knee Prosthesis

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Purpose: Primary revision total knee arthroplasty (TKA) is associated with bone loss and ligamentous insufficiency. After TKA, patients may have global knee instability or genu recurvatum and require revision TKA with a rotating-hinged knee (RHK) prosthesis. However, several studies have reported variable outcomes. This study aimed to: 1) evaluate the outcomes of revision TKA with an RHK prosthesis; and 2) compare the outcomes and satisfaction of patients with global instability and genu recurvatum following revision TKA.

Methods: The cases of 18 patients (mean age, 71 ± 8.5 years; mean follow-up time, 24 months (range, 12–38 months) who underwent revision TKA with an RHK prosthesis in 2015–2018 were retrospectively reviewed. Patients were further classified into the global instability group (n=11), those who were diagnosed with periprosthetic joint infection (8 patients), TKA dislocation (2 patients), and periprosthetic fracture with a complete tear of the medial collateral ligament (1 patient); and the genu recurvatum group (n=7). Clinical evaluations were performed preoperatively, at 1 year postoperative, and at the last follow-up. Outcomes were assessed using the Knee injury and Osteoarthritis Outcome Score (KOOS), pain visual analog scale (VAS), range of motion (ROM), complications, and radiographic data. Patient satisfaction was assessed at the 1-year follow-up using a self-administered scale.

Results: Overall, the mean KOOS at the 1-year follow-up was significantly improved versus preoperative (71.39 ± 8.65 vs. 22.56 ± 11.58, p<0.001). The mean 1-year postoperative KOOS (50 vs. 47, p=0.028), surgical satisfaction score (p=0.005), home activity satisfaction score (p=0.0029), and recreational activity satisfaction score (p=0.024) were significantly higher in the global instability versus genu recurvatum group, whereas the mean pain VAS score was significantly higher in the global instability versus genu recurvatum group (6 vs. 4, p=0.037). The mean ROM improved from 30° to 90° in the global instability group and from -20° to 0° in the genu recurvatum group. No surgical complications or signs of prosthesis loosening were observed.

Conclusions: Revision TKA with an RHK prosthesis showed better functional outcomes in patients with global instability versus genu recurvatum. Furthermore, patients with global instability showed higher satisfaction with surgery, home, and recreational activities than those with genu recurvatum.

Keywords: rotating-hinged knee prosthesis, recurvatum after primary TKA, global instability, functional outcome, patient satisfaction

Article history:
Received: October 8, 2022, Revised: March 9, 2023
Accepted: April 18, 2023

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Revision total knee arthroplasty (TKA) is challenging, and its incidence is steadily increasing. Some authors estimate that the number of revision TKA will increase by 601% in 2030 versus 2005. The most common etiologies for revision TKA are infection (36.1%), aseptic loosening (21.6%), periprosthetic fracture (13.7%), and instability (6.7%) [1,2]. Conventional implants are used in most cases, but some patients present with severe deformities, severe involvement of the ligamentous structure, or bone loss requiring a more constrained implant [3].

Fixed-hinge prostheses have the disadvantages of higher stress transmission to the bone–implant interface, a high rate of failure, and frequent complications including infection, loosening, and component failure [4]. The rotating-hinge knee (RHK) prosthesis is the evolution of a fixed-hinge model that combines flexion–extension movement with axial rotation to improve mechanics and decrease stress transmission [5]. Several indications exist for the use of RHK prostheses, including severe primary knee osteoarthritis with neuromascular disorders, rheumatoid arthritis, and severe bone loss. In revision TKA, the RHK prosthesis is necessary to resolve severe bone loss following infection or aseptic loosening, instability including global instability, and genu recurvatum [6,7].

Global instability, defined as instability in all planes, can occur after periprosthetic joint infection, aseptic loosening, and severe bone loss. In more severe cases of global instability, symmetrical and balanced flexion and extension gaps may not be achievable and an RHK prosthesis may be necessary [8,9]. The outcomes of revision TKA using RHK prostheses in patients with global instability vary. Some studies showed excellent outcomes [10,11], while others showed a high complication rate. In a series with a high complication rate, postoperative infection, the most frequent complication, occurred in approximately 45% of patients [12].

Genu recurvatum (hyperextension instability) occurs in only 0.5–1% of patients undergoing TKA [13]. Patients with severe recurvatum (hyperextension > 10°) after TKA have the worst functional outcomes and highest risk of revision surgery for laxity [14]. Genu recurvatum may require the use of a lifelong brace, an RHK prosthesis, or arthrodesis [15]. Cottino et al. [8] recommended the use of an RHK prosthesis with an extension stop to reduce the risk of postoperative hyperextension instability. In patients with poliomyelitis or neuromuscular disease, genu recurvatum presents as a result of quadriceps weakness and ankle equinus, which is compensated for by walking with the knee locked in hyperextension. An RHK prosthesis can be used in these patients [16]. Data are limited on the outcomes of revision TKA with RHK in patients with postoperative genu recurvatum and consist of only case series or case reports [16,17], which showed successful outcomes.

Patients with global instability and severe genu recurvatum after TKA are treated with an RHK prosthesis. However, different etiologies may result in varying outcomes. No studies to date have documented differences in outcomes or satisfaction among groups. We performed a retrospective study to evaluate and compare the outcomes of revision TKA using an RHK prosthesis including satisfaction of patients with global instability versus genu recurvatum.

MATERIALS AND METHODS

This retrospective study received institutional review board approval (no. R186h/62) and included all patients who underwent revision TKA using RHK prostheses (S-ROM RHK prosthesis; DePuy Orthopedics, Johnson & Johnson Co., Warsaw, IN, USA; S-ROM design group) between January 2015 and January 2018. Patients were classified into two groups: group 1, global instability after TKA; and group 2, genu recurvatum (hyperextension > 20°) after TKA (Figure 1). The exclusion criteria were revision TKA not treated with the S-ROM design and unreachable. The S-ROM RHK prosthesis Figure 2) was used by the same surgeon at our hospital for all patients. Eighteen patients underwent revision TKA using the medial parapatellar approach and received perioperative antibiotic prophylaxis (cefazolin 2–3 g). In the case of two-stage revision arthroplasty due to a periprosthetic joint infection, antibiotic therapy was chosen according to microbiological cultures and sensitivity and administered for at least 6 weeks between revision stages and for 12

weeks after the second-stage procedure using the S-ROM RHK prosthesis.

Fig. 1 An 82-year-old woman with knee instability following total knee arthroplasty. (A) Valgus–varus stress test for assessment of collateral ligaments of the knee. (B) Intraoperative image of complete tear of the medial collateral ligament.

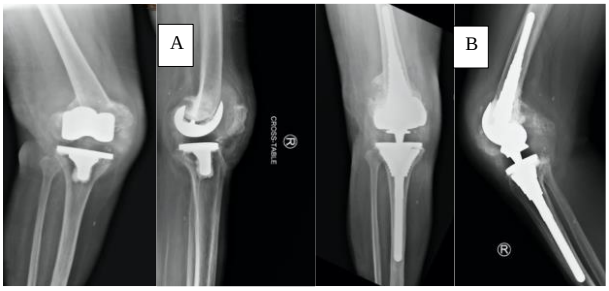

Fig. 2 (A) Preoperative radiographs showing the supracondylar periprosthetic fracture with insufficiency of the medial collateral ligament. (B) Radiographs taken after implantation of an S-ROM rotating-hinge knee prosthesis (DePuy Orthopedics) confirming favorable composition.

We collected the data by reviewing the outpatient department card and operative notes and filled in the incomplete data by telephoning. Demographic data included sex, age, body mass index, comorbidities, cause of revision, and follow-up duration. Patient outcomes were evaluated using the Knee injury and Osteoarthritis Outcome Score (KOOS) and pain visual analog scale (VAS). Range of motion (ROM) was measured passively using a goniometer with the patient in the supine position. The Thai version of the KOOS was created and validated by Chaipinyo in 2009 [18]. Examinations were recorded before surgery, at 1 year postoperative, and at the last postoperative follow-up. At 1 year postoperative, patient satisfaction was assessed using a self-administered satisfaction scale consisting of four criteria focusing on the patient's overall satisfaction with surgery, pain relief, ability to do home or yard work, and ability to engage in recreational activities [19,20]. Serial standard antero-posterior and lateral radiographs of the knees were reviewed, including the assessment of alignment, signs of loosening such as component migration, radiolucent lines, presence of cement fracture or periprosthetic fracture, and osteolysis. Complications included surgical site infection, periprosthetic joint infection, periprosthetic fracture, extensor mechanism problems, aseptic loosening, implant failure, instability, or neurovascular problems.

Demographic data are expressed as number and percentage or mean ± standard deviation. The results were based on functional scores, including the KOOS. The pre- and postoperative KOOS scores were compared using the Wilcoxon signed-rank U test. The KOOS were compared between groups using the Mann-Whitney U test (significance at $p < 0.05$). The ROM was described in detail between pre- and postoperative revision TKA for each group. Patient satisfaction scores were compared between groups using the chi-squared test with values of $p < 0.05$ considered statistically significant. The statistical analyses were performed using STATA version 12 (StataCorp LLC, College Station, TX, USA).

RESULTS

Eighteen patients underwent revision TKA using the S-ROM RHK. The indications were global instability in 11 (61%) patients and genu recurvetum after TKA in seven (39%) patients. The patients' demographic data are summarized in Table 1. The minimum follow-up period was 12 months, while the mean follow-up duration was 24 (range, 12–38) months. The mean KOOS at 1-year follow-up in all patients was significantly improved versus preoperative (71.39 ± 8.65 vs. 22.56 ± 11.58, $p<0.001$). The mean VAS score significantly improved in all patients (6.50 ± 2.12 vs. 1.11 ± 1.13, $p<0.001$) (Table 2). The 1-year postoperative KOOS was significantly higher in patients with global instability than in those with genu recurvatum after TKA (50 vs. 47, $p=0.028$). Although the mean pain

VAS score was significantly improved in both groups, it was significantly higher in the global instability versus genu recurvatum group (5.91 ± 1.14 vs. 4.57 ± 1.13, respectively; p=0.037). Additionally, the mean ROM improved compared to the preoperative value in both groups (30° to 90° in the global instability group and -20° to 0° in the genu recurvatum group). No signs of prosthetic loosening or subsidence were observed at 1 year postoperative or at the last follow-up in either group. No surgical complications (surgical site infection, periprosthetic joint infection, periprosthetic fracture, extensor mechanism problem, or neurapraxia) occurred in either group.

Table 1 Demographic data of patients who underwent rotating-hinge knee prosthesis implantation.

Characteristic	Data
Patients (knees)	18
Age, years	71.67 ± 8.64
Body mass index	25.15 ± 3.35
Sex	
Female	13 (72%)
Male	5 (28%)
Comorbidity	
Hypertension	15 (83%)
Diabetes mellitus	5 (27%)
Rheumatoid arthritis	1 (5%)
Other	7 (38%)
Indication	
Genu recurvatum	7 (39%)
Global instability	11 (61%)
Periprosthetic joint infection	8 (73%)
Knee dislocation	2 (18%)
Supracondylar periprosthetic fracture with complete tear of medial collateral ligament	1 (9%)

Data are shown as mean ± standard deviation or n (%) as appropriate. "Other" conditions include dyslipidemia, chronic obstructive pulmonary disease, ischemic heart disease, and chronic kidney disease.

Table 2 Mean pre- and postoperative KOOS and VAS of all patients at 1-year follow-up.

Score	Preoperative	Postoperative	P value
	Mean ± SD	Mean ± SD	
KOOS	22.56 ± 11.58	71.39 ± 8.65	<0.001
VAS	6.50 ± 2.12	1.11 ± 1.13	<0.001

KOOS, Knee injury and Osteoarthritis Outcome Score; VAS, visual analog scale; SD, standard deviation

Table 3 Mean KOOS and VAS scores of the global instability versus genu recurvatum groups at 1-year follow-up.

Time	Global instability	Genu recurvatum	P value
	Mean ± SD	Mean ± SD	
Preoperative KOOS	17.45 ± 5.15	30.57 ± 14.6	0.013
Preoperative VAS	7.36 ± 1.63	5.14 ± 2.19	0.027
Δ pre- vs. postoperative	50.91 ± 4.72	45.57 ±5.29	0.028
Δ pre- vs. postoperative VAS	5.91 ± 1.14	4.57 ± 1.13	0.037

KOOS, Knee injury and Osteoarthritis Outcome Score; VAS, visual analog scale; SD, standard deviation

Patient satisfaction was significantly different between groups, except for satisfaction with pain (Figure 3). The global instability group had significantly higher satisfaction scores for home and recreational activities than the recurvetum group (p=0.029 and p=0.024, respectively), including satisfaction with the surgery (p=0.005).

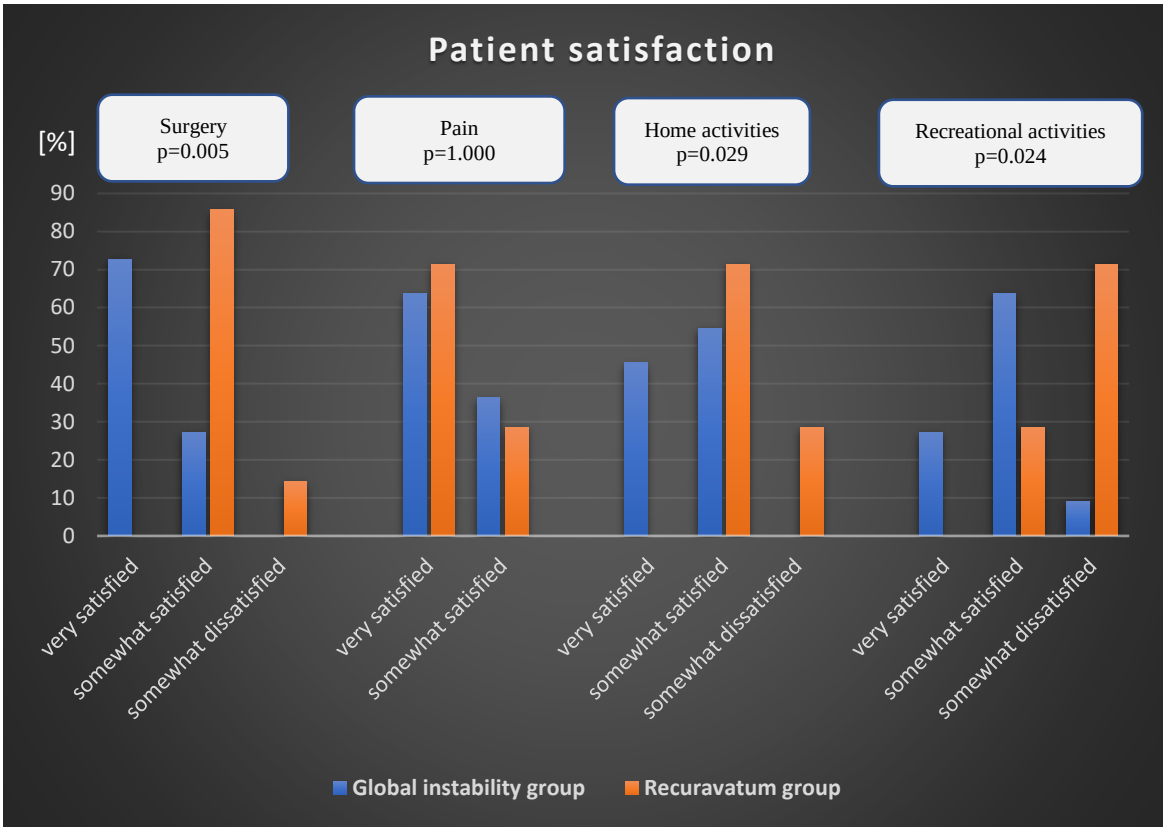

Fig. 3 Patient satisfaction in the global instability versus genu recurvatum groups.

DISCUSSION

At the short-term follow-up, revision TKA with the RHK prosthesis in our study resulted in good outcomes. All patients showed improved functional scores and satisfaction. The outcomes of RHK prosthesis in revision TKA were evaluated in several studies, with results varying from poor to good. Neumann et al. [21] reported a small series of 24 patients with improved functional scores. No implant loosening was observed, and only one patient required revision due to patellofemoral subluxation. Bistolfi et al. [22] studied 33 revision patients; almost half of them developed postoperative complications, while three required re-revision. In a larger series of 79 knees, Kearns SM et al. [23] reported a complication rate of 38.7% (periprosthetic joint infection, periprosthetic fracture, and extensor mechanism rupture) and defined periprosthetic joint infection as the most frequent complication of the RHK prosthesis, while our study had no cases of periprosthetic joint infection at the final follow-up, probably because of our strict perioperative management. In a previous study, Deehan et al. [24] reported 36 S-ROM hinge prostheses (four primary, 33 revision), of whom four patients required patellar resurfacing for persistent pain. Although this study defined anterior knee pain after RHK prosthesis placement, no incidence of anterior knee pain was observed in our study because all patients underwent patellar resurfacing without patellar maltracking.

Barrack et al. [4] reported satisfactory results in a series of 23 knees (S-ROM RHK) after 2–9 years of follow-up; all but one patient indicated satisfaction with the surgery or the degree of pain relief and function. In our study, patient satisfaction differed among subcategories. Patients with global instability were significantly more satisfied with their home and recreational activities, but not with their pain. This is probably because patients with global instability may be more susceptible to their pathologies than those with genu recurvatum, including completely limited daily and soft sports activities. After revision TKA, all patients showed improved functional outcomes and returned to their normal activities; thus, they were more satisfied.

Our study has some limitations. First, it included a small number of patients from a single institution, which does not allow conclusions about the definitive outcome of the RHK prosthesis (S-ROM design) to be drawn. Second, the follow-up period was short, with a mean follow-up period of 24 months and a minimum of 12 months. Mid- to long-term follow-up should be performed to draw definitive conclusions about complications and survival rates.

CONCLUSIONS

This study demonstrated that the S-ROM RHK prosthesis provided good functional and radiologic outcomes and high satisfaction at short-term follow-up. Revision TKA with an RHK prosthesis showed better functional outcomes for patients with global instability than those with genu recurvatum following TKA. Furthermore, the former group showed higher satisfaction with home and recreational activities. We believe that good surgical technique and good perioperative care are key elements to good outcomes after revision TKA with an RHK prosthesis.

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