

Management and clinical outcomes of periprosthetic fractures after total knee arthroplasty with a stem extension

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Abstract

There is little information about the management and clinical outcomes of the periprosthetic fracture after total knee arthroplasty (TKA) with a stem extension. The purposes of this study were to demonstrate management of the periprosthetic fractures after TKA with a stem extension, to report treatment outcomes, and to determine whether dual-plate fixation is superior to single-plate fixation regarding the radiographic bone union time and incidence of metal failure.

This retrospective study included 15 knees with periprosthetic fractures after TKA using a stem extension. We demonstrated the fracture characteristics and management according to the fracture location and implant stability. The radiographic union time was determined. Complications, range of motion, and functional outcomes, including Western Ontario and McMaster Universities Osteoarthritis Index and Knee Society Score were assessed. Periprosthetic fractures after TKA with stem extension were 1 metaphyseal fracture without implant loosening, 7 diaphyseal fractures adjacent to the stem without implant loosening, 3 diaphyseal fractures away from the stem without implant loosening, and 4 fractures with implant loosening.

Treatment included immobilization using a long leg cast, open reduction and internal fixation (ORIF), and re-revision TKA. There was no difference in functional outcomes and range of motion pre- and posttreatment. The complications included 2 cases of subsequent implant loosening. Patients in the dual-plating required a shorter bony union time than those in the single-plating (2.4 ± 1.1 vs 7.4 ± 2.2 months; $P = .003$).

Periprosthetic fractures after TKA with stem extension could be managed individually according to the fracture location and implant stability. Complications were not uncommon even if patients were able to return to their preinjury functional level posttreatment. To avoid complications after ORIF, the dual plate was superior to the single plate, and subtle implant loosening should not be overlooked.

Abbreviations: AP = anteroposterior, FC = flexion contracture, FF = further flexion, KSS = Knee Society Score, ORIF = open reduction and internal fixation, TKA = total knee arthroplasty, WOMAC = Western Ontario and McMaster Universities Osteoarthritis Index.

Keywords: management, periprosthetic fracture, stem extension, total knee arthroplasty

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JHS and MJC have contributed equally to this work.

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1. Introduction

Total knee arthroplasty (TKA) has provided high long-term survival rates and excellent outcomes.^[1–3] However, revision surgery using a prosthesis with a stem extension is sometimes necessary to treat complications such as periprosthetic joint infection, aseptic loosening, or periprosthetic fracture.^[4–9] In addition, a prosthesis with a stem extension might be helpful for a complicated, arthritic knee with a severe deformity and/or a large bone defect. Therefore, as the number of primary TKAs increases, the number of knees that need a stem extension is also increasing.^[10–14]

As the number of knees that need a stem extension increases, the number of periprosthetic fractures in patients who undergo TKA with a stem extension has increased.^[15] The incidence of periprosthetic fracture after primary TKA ranges between 0.3% and 2.5%. In contrast, the incidence ranges between 1.6% and 38% after revision TKA with a stem extension.^[15,16] The reason for the higher rate of periprosthetic fracture in patients who underwent revision TKA is probably because patients with revision TKA are generally older, osteoporotic, and have a compromised vascular supply due to repeated surgeries.^[15,17] Additionally, stress shielding along the stem is probably one of the reasons for the increased incidence of periprosthetic fractures after TKA with a stem extension.^[18]

Many factors must be considered regarding fractures in patients who underwent TKA with a stem extension, such as the fracture location, type of fracture, prosthesis stability, and bone defect. However, there is limited information about the management and clinical outcome of periprosthetic fractures after TKA with a stem extension.

The purposes of this study were to demonstrate the management of periprosthetic fractures after TKA with a stem extension and report the treatment outcomes of periprosthetic fractures regarding functional outcomes, range of motion (ROM), and complications. Furthermore, we sought to determine whether dual-plate fixation is superior to single-plate fixation regarding the time required for radiographic bone union and the incidence of metal failure. We hypothesized that periprosthetic fractures after TKA with a stem extension could be managed individually according to the fracture location and stem stability. We also hypothesized that the functional outcome and ROM would be substantially worse, with a high rate of complications after surgery for periprosthetic fracture. In addition, we assumed that patients in the dual-plate group would need a shorter time to obtain radiographic bone union than those in the single-plate group.

2. Methods

After obtaining institutional review board approval and patient consent, we reviewed the medical records and radiographs of patients who underwent treatment for periprosthetic fractures after TKA with a stem extension. Between January 2008 and December 2017, 15 knees (15 patients) had a periprosthetic fracture after TKA using a stem extension. All of these knees were included in this retrospective study. All patients underwent revision TKA. Seven revision surgeries were for periprosthetic joint infection, 4 were for aseptic loosening. There were 13 female and 2 male patients. All the fractures were femoral periprosthetic fractures. The mechanism of injury was falling in all knees. The average age of the patients was 70 years (range, 60–86 years) at the time the periprosthetic fracture occurred. On average, the periprosthetic fracture occurred 34 months (range, 1–92 months) after revision TKA was performed. Periprosthetic fractures after TKA with stem extension were 1 metaphyseal fracture without implant loosening (Fig. 1A), 7 diaphyseal fractures adjacent to the stem without implant loosening (Fig. 2A), 3 diaphyseal fractures away from the stem without implant loosening (Fig. 3A), and 4 fractures with implant loosening (Fig. 4A). The characteristics of the periprosthetic fractures after TKA with a stem extension are shown in Table 1.

In terms of treatment strategies, we applied a long leg cast to conservatively treat patients. In addition, we used open reduction and internal fixation (ORIF) with a locking compression plate to operatively treat patients with fractures without loosening. However, if implant loosening occurred, revision TKA was performed. We determined that implant loosening had occurred when there was a radiolucent line that was at least 2 mm between the bone and implant, as seen on a conventional radiograph. Postoperative rehabilitation was performed using the same protocol for all patients. In patients who underwent an operation, continuous passive motion was performed from the second day after surgery until the patients were discharged. ROM of the knee joint was allowed as tolerated. The patients were discharged at 1 week postoperatively. Full weight bearing was allowed at 6 weeks postoperatively. However, for patients who did not undergo



Figure 1. A metaphyseal periprosthetic fracture without implant loosening after revision total knee arthroplasty with a stem extension. (A) There was a metaphyseal liner fracture without implant loosening. (B) The fracture healed using conservative treatment with a long leg cast.

surgery, only a long leg cast with non-weight bearing was applied, and the patients were discharged the next day. Non-weight bearing was maintained until 6 weeks after the trauma, and full weight bearing was allowed at 3 months postoperatively.

Independent clinical investigators performed clinical and radiographic evaluations every 2 weeks until 3 months posttreatment, every 3 months until 1 year, and annually after 1 year. Anteroposterior (AP) and lateral radiographs of the femur and lower leg were used for the radiographic evaluation. The period of union of the fracture was determined by confirming the formation of callus-crossing fragments on both AP and lateral radiographs. We reviewed the complications and functional outcomes after treating the periprosthetic fractures by assessing the flexion contracture (FC), further flexion (FF), and the Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC) score, Knee Society Score (KSS) knee score, and KSS functional score at every outpatient visit. The FC and FF of the knee joint were measured using a goniometer with the patient in a supine position. We used WOMAC, KSS knee, and KSS functional score which were checked at the last visit before fracture as preoperative variables and the scores that were checked at last follow-up after management of the fracture as postoperative variables. These variables were used to compare the differences between the pre- and postoperative functional outcome and ROM.

The statistical analysis was performed using SPSS software (Version 20.0; SPSS Inc., Chicago, IL). *P*-values <.05 were



Figure 2. A diaphyseal periprosthetic fracture adjacent to the stem without implant loosening after revision total knee arthroplasty with a stem extension. (A) A diaphyseal fracture was adjacent to the stem, without implant loosening. (B) Open reduction and internal fixation was performed using dual plates.



Figure 3. A diaphyseal periprosthetic fracture away from the stem without implant loosening after revision total knee arthroplasty with a stem extension. (A) A transverse fracture was proximal to the femoral stem. (B) Open reduction and internal fixation was performed using dual plates.

considered statistically significant. Age, the time required for radiographic bone union, and functional outcome, including the WOMAC, KSS knee score, KSS functional score, FF, and FC, are presented as means and standard deviations. Sex, fracture location, fracture patterns, treatment methods, and complications are presented using numbers and proportions. To evaluate the difference of the bony union period between the single-plate group and dual-locking plate group, we used an independent samples *t* test. In addition, a paired *t* test was used to determine the statistical significance of the difference in functional outcomes (WOMAC, KSS knee score, KSS functional score, FF, and FC) between before and after treatment of the fractures. The raw WOMAC scores were converted into a 0 (worst) to 100 (best) point scale. In the statistical power analysis, we estimated that the sample size of this study was adequate to achieve a statistical power of 99%, with less than a 5% probability of a type I error and a 95% confidence interval.

3. Results

Conservative treatment with a long leg cast was used for a metaphyseal fracture without implant loosening (Fig. 1), ORIF with a single or dual plate was used for diaphyseal fractures without implant loosening (Figs. 2 and 3), and re-revision TKA was performed for fractures with implant loosening (Fig. 4).

In terms of the functional outcomes, the WOMAC and KSS knee and functional scores were worse after fracture management

than before, but the difference was not statistically significant. In addition, there was no significant difference between the preoperative and postoperative ROM of the knee (Table 2). Two (13%) complications occurred after treatment. Two patients had implant loosening. Among the 2 patients who experienced subsequent implant loosening, one of them experienced loosening 20 months after fixation of the diaphyseal fracture without implant loosening. In the other case, loosening occurred about 4 years after the patient was treated with a hinged prosthesis for the fracture with implant loosening. Re-revision TKA was needed in these 2 patients, with subsequent implant loosening.

Patients in the dual-plate group had a shorter bony union period than those in the single-plate group (2.4 ± 1.1 vs 7.4 ± 2.2 months, respectively; $P = .003$). Nine patients with periprosthetic fractures were treated with ORIF. Among them, fixation with a single locking plate was performed in 3 patients, and the remaining 6 were managed with dual locking plate fixation.

4. Discussion

Although the number of periprosthetic fractures after TKA with a stem extension has been increased, there are few reports on the management and clinical outcomes of periprosthetic fractures after TKA with a stem extension. Therefore, we reviewed the management of the periprosthetic fracture after TKA with a stem extension. In addition, we reported on the postoperative



Figure 4. A periprosthetic fracture with implant loosening after revision total knee arthroplasty with a stem extension. (A) There was a metaphyseal, comminuted fracture with femoral component loosening. (B) Re-revision total knee arthroplasty was performed using a rotating hinged knee prosthesis with a longer stem extension.

outcomes and complications. This study has several principal findings. First, metaphyseal periprosthetic fractures after TKA with a stem extension were usually combined with metaphyseal

Table 2

The functional outcomes of patients with periprosthetic fractures after TKA with a stem extension.

	Preoperative	Postoperative	P-value
WOMAC	58.3 ± 12.8	40.2 ± 21.0	.762
KSS knee score	79.4 ± 19.3	66.4 ± 14.6	.280
KSS functional score	52.8 ± 13.7	64.8 ± 20.4	.765
FF, °	98 ± 9.8	112.1 ± 17.7	.917
FC, °	1.0 ± 2.0	2.9 ± 6.0	.510

Data are presented as the means and standard deviations. FC=flexion contracture, FF=further flexion, KSS=Knee Society Score, TKA=total knee arthroplasty, WOMAC=the Western Ontario and McMaster Universities Osteoarthritis Index.

comminution, and it was difficult to fix the condyle in the original position. These fractures frequently cause subsequent collateral ligament insufficiency. Therefore, re-revision surgery using a prosthesis with an increased level of constraint might be needed. Second, if periprosthetic fractures occurred after TKA with a stem extension, it was difficult to determine whether subtle implant loosening existed or not. Therefore, revision TKA with a longer stem should be considered if the implant stability is uncertain. Third, it was sometimes difficult to obtain enough fixation strength using a single plate. We found that dual plating provided better fracture stability than single plating and shortened the union period.

Similar to the Vancouver system for classifying periprosthetic fractures that occur after THA, the classification was also based on the fracture location and implant stability. The fracture location was divided into the metaphysis, diaphysis adjacent to the stem, and diaphysis away from the stem within 5 cm.^[19] If the implant was unstable, the fracture location was not used to classify the fractures. In patients with a type I fracture, a stem can provide enough implant stability. Therefore, if the fracture is limited to the metaphysis and there is no implant loosening, conservative management can be used. In type II and III fractures, it is reasonable to perform ORIF, despite the results of a previous study that used re-revision TKA with a longer stem and allograft augmentation to treat type II fractures.^[20] In the present study, all

Table 1

The characteristics of patients with periprosthetic fracture after TKA with a stem extension.

	MF without IL	DF adjacent to stem without IL	DF away from stem without IL	Fracture with IL
Number	1	7	3	4
Sex (male: female)	0:1	0:7	1:2	1:3
Age, y*	73	72.4 ± 8.1	65.6 ± 3.1	69 ± 4.7
Fracture patterns				
Oblique	1	1	1	0
Spiral	0	3	0	1
Transverse	0	3	2	0
Comminuted	0	0	0	3
Treatments				
Conservative	1	0	0	0
ORIF	0	7	3	0
Re-revision	0	0	0	4
Complications				
Metal failure	0	0	0	0
PJI	0	0	0	0
Loosening	0	0	0	2

Data are presented as the numbers of patients and percentages. DF=diaphyseal fracture, IL=implant loosening, MF=metaphyseal fracture, ORIF=open reduction and internal fixation, PJI=periprosthetic joint infection, TKA=total knee arthroplasty.

*Data are presented as the means and standard deviations.

type IV fractures were comminuted, metaphyseal fractures. It is thought that those fractures can cause collateral ligament insufficiency. Therefore, as we mentioned above, a constrained implant such as a rotating, hinged prosthesis might be used to stabilize the replaced knee. However, in some cases, a surgery for fractures is prior to a revision for loosening. Also, if a revision surgery is performed in a fracture with loosening, implant fixation may not be firm. Therefore, it may be a viable option to perform ORIF for fractures first and a revision surgery when loosening progresses after ORIF for fractures.

In terms of treatment outcomes, the findings of this study did not support the hypothesis that the functional outcomes and ROM would become worse after treatment. Several studies showed that there was a poor functional outcome after treatment of periprosthetic fractures that occurred following primary TKA.^[21,22] In this study, the postoperative functional outcomes were also worse than the preoperative outcomes, but the difference was not statistically significant. This contradictory finding is because the functional scores of the patients who were included in this study were generally worse than those with primary TKA. All of the patients who were included in this study underwent revision surgery because of aseptic or septic loosening that occurred after primary TKA. Thus, these patients already had a poorer functional outcome than those who underwent primary TKA alone. This indicates that surgeons should focus on obtaining bony union of the fractures with less concern for functional impairment after treatment.

Our findings support the hypothesis that patients in the dual-plate group would need a shorter time to obtain radiographic bone union than those in the single-plate group. In the previous study using osteoporotic patients with Su type III fractures after TKA, the authors of the previous study obtained satisfactory clinical and radiological outcomes with application of double locking plate and screw.^[23] Even if fracture types in our study were different with those in the previous study, the periprosthetic fracture around the stem and osteoporotic Su type III fracture are similar in that it is difficult to achieve secure fixation using single plate. Thus, the results of the previous study indirectly support our findings. In addition, considering that there was study reporting satisfactory surgical outcome after using nail-plate constructs for periprosthetic distal femur fractures, it is thought that providing sufficient fixation force is necessary to obtain satisfactory surgical results.^[24]

This study has several limitations. First, this is a retrospective study that included a small number of subjects. However, considering that the occurrence of periprosthetic fracture after TKA with a stem extension is uncommon, the number of cases in our study is relatively large. Second, it would be better if there were a control group that was comprised of patients with periprosthetic fractures after primary TKA. In addition, we were not able to analyze the predicting factor for outcome after surgery. However, this study focused on classifying periprosthetic fractures after TKA with a stem extension and reporting the treatment outcome. A strength of the current study is that we were able to classify the rare periprosthetic fracture cases into 4 types. There is limited information of periprosthetic fracture classification in patients underwent TKA with stem extension. One previous study about new classification for femoral periprosthetic fractures after TKA included a transverse fracture occurring around the tip of the stem extension attached to the revision implant in their classification.^[13] However, they did not

further classify the fractures around the stem. We think that our classification can provide useful information to readers.

In conclusion, periprosthetic fractures after TKA with a stem extension could be managed individually according to the fracture location and implant stability. Complications were not uncommon, even if the patients were able to return to their pre-injury functional level after treatment. To avoid complications, a dual plate was superior to a single plate when performing ORIF, and subtle implant loosening should not be overlooked.

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