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Functional Outcome of Total Knee Arthroplasty After Periprosthetic Distal Femoral Fracture

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ABSTRACT

A prospective matched cohort study was performed to compare functional outcomes between 28 patients with periprosthetic femoral fractures and 28 with primary total knee arthroplasties (TKA). The mean follow-up was 6.7 years (range, 5–9). Radiographic osteopenia was a predisposing factor, but not notching, body mass index, or preinjury knee scores or motion. At last follow-up, the Knee Society scores, knee motion, Womac, and SF-12 were significantly lower in the fracture group, and were significantly decreased compared to the preinjury status. We found that periprosthetic distal femoral fracture after TKA worsens functional outcomes at the medium term, but arthroplasty complication and survival rates were similar in both groups.
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Periprosthetic fracture of the distal femur is an infrequent but devastating complication after total knee arthroplasty (TKA). Nonoperative treatment of displaced fractures is associated with a high complication rate [1], but there is no consensus on the best surgical treatment for these fractures [2]. Various fixation methods are available, such as blade plate, dynamic condylar screw, locking condylar plate or retrograde intramedullary nail, but none has yielded consistently acceptable results [3]. The goals of the surgical treatment for these displaced fractures are to provide stable fixation for fracture healing in proper alignment, allowing early mobilisation of the knee, preserving a painless range of knee motion, and return to pre-injury level of ambulation [4]. Most studies on the treatment of these fractures have been small retrospective series with a follow-up relatively short (less than 2.5 years on mean) [5–7]. To our knowledge, only one previous study [8] has been reported on a prospective series of periprosthetic fractures after TKA, and this had a mean follow-up of 15 months. In addition, these studies focus on diverse fracture fixation techniques and in relation to the fracture healing and the surgical and mechanical results, but postoperative knee outcomes have not usually been well documented. Periprosthetic fracture is a serious injury to the knee that may influence the clinical outcome of the arthroplasty but, to our knowledge, there has not been a study specifically evaluating the functional outcomes of the TKA after periprosthetic fracture at the medium or long term.

Therefore, the aim of this study was to evaluate prospectively the clinical outcomes of patients with TKA after periprosthetic distal femoral fractures with a minimum follow-up of 5 years after injury.

Material and Methods

We obtained approval to perform this study from our institutional review board. Between 2000 and 2007, 31 consecutive periprosthetic femoral fractures after TKA were prospectively assessed with a minimum follow-up of 5 postinjury years. Of these, 3 patients were excluded. One patient died at 10 postinjury months (bronchopneumonia) with the fracture healed and stable TKA. Another two patients had nonoperative treatments (one nondisplaced fracture, and one patient with displaced fracture and anesthetic risk). Demographic and preoperative data of the remaining 28 patients are shown in Table 1.

All index TKAs had been performed at our institution between 1990 and 2006 and the primary diagnosis was osteoarthritis in all patients. At the time of the fracture, 26 patients had a primary TKA, and 2 had revision arthroplasties at 6 and 8 years from the primary TKA (tibial insert change and aseptic tibial loosening, respectively). The arthroplasty models included 12 Axiom (Wright Medical, Arlington, TN, USA), 11 Duracon (Stryker-DePuy, Warsaw, IN, USA) and 5 Multigen (Lima, San Daniele, Italy). Excluding the intraoperative fracture, the mean interval to fracture after primary arthroplasty was 7.3 years (range, 2.7–15), and after revision arthroplasty was 2.8 years (range, 1.7–3.9). In one patient the fracture occurred intraoperatively, in 22 it resulted after falls from standing position, in 4 after falls down stairs, and in 1 after traffic accident. According to the Rorabeck and Taylor [4] and AO [9] classifications, 1 periposthetic fracture was type-I (intraoperative fracture, AO-33B1), 24 were type-II (5 AO-33A1, 12 AO-33A2, 7 AO-33A3), and 3 were type-III (3 A0-33A3). All fractures were closed, and no neurovascular injury was detected. All fractures occurred above cementless cruciate-retaining TKA.

As a control group, for each case a patient who had received a primary TKA at the time of injury was matched on primary diagnostic of osteoarthritis, gender and age (± 1 year). Precise matching of the

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Table 1
Demographic and Preoperative Data.

	Fractured	Controls	*P*
Age	75.6 (56–86; 6.2)	75.1 (55–85; 5.9)	0.758
Gender: F/M	26/2	26/2	
BMI, kg/m^2	31.7 (25.0–43.8; 4.4)	31.8 (23.8–40.9; 5.1)	0.941
Osteopenia	11	4	0.034
Knee ROM[a]	107.3 (90–130; 12.2)	89.1 (65–120; 24.4)	0.001
KS knee score[a]	89.5 (75–100; 6.0)	32.0 (11–68; 9.8)	0.001
KS functional score[a]	90.0 (80–100; 7.9)	39.3 (10–70; 17.9)	0.001
Womac pain[a]	79.6 (60–100; 12.7)	22.6 (0–50; 12.6)	0.001
Womac function[a]	78.4 (50–100; 10.6)	20.4 (0–30; 14.3)	0.001
SF12 physical[a]	44.8 (38–50; 7.7)	24.7 (6–38; 10.6)	0.001
SF12 mental[a]	45.7 (28–50; 9.9)	22.6 (6–33; 12.3)	0.001

Data are presented as mean (range; standard deviation), unless otherwise stated.
[a] Range of motion (ROM), Knee Society (KS) scores, Womac, and SF12: before injury in fractured; before arthroplasty in controls.

model of arthroplasty could not be carried out because at the time of the fracture some models had ceased to be used at our institution. Data of both groups are shown in Table 1. In both groups, the most common comorbidities were diabetes (28.5%), hypertension (21.4%) and heart disease (10.7%).

Operative Procedure

The mean time from fracture to surgery was 2.7 days (range, 2–6). All operations were performed under spinal anaesthesia in an operating room with laminar flow. Treatment options varied, because this depended on the type of fracture. For the 3 AO-33A3/Rorabeck-III fractures, the arthroplasty were revised to hinged TKA (Endo-Model, Waldemar Link, Hamburg, Germany). For 12 AO-33A2/Rorabeck-II fractures, a retrograde intramedullary nail (T2, Stryker, Geneve, Switzerland) was used, for 5 AO-32A1/Rorabeck-II fractures, a locking condylar plate (Liss, Synthes, Bettlach, Switzerland), for 7 AO-33A3/Rorabeck-II, a dynamic condylar screw (Nolok 95º, Depuy, Leeds, England), and for intraoperative AO-33B1/Rorabeck-I fracture, compression screws (ORIF, Synthes, Bettlach, Switzerland). In all cases, open fracture reduction was performed, and the techniques used for internal fixation were those described for each one of the devices. All patients were treated with a similar perioperative protocol. Antibiotic prophylaxis was with first generation cephalosporin for 24 postoperative hours and thromboprophylaxis with low molecular weight heparin for 30 postoperative days. Continuous passive knee motion started on the first postoperative day, and from the third day active motion. Full weight-bearing was allowed when bridging callus was seen on the follow-up radiographs. No postoperative bracing was used.

Evaluations

At our institution, the total joint registry prospectively collects clinical and radiographic data on all patients treated with arthroplasty. Standardized assessment was performed preoperatively and postoperatively at six weeks, 3, 6, and 12 months, and then annually until at least five postoperative years. The fracture patients were assessed postoperatively at 6 and 12 weeks, and then monthly until fracture healing or failure, then at 6 months, and after annually until at least five postoperative years. Clinical evaluations at each follow-up were performed by specially trained independent fellows by the Knee Society scores [10]. Annually, all patients were requested short-form Womac [11] and SF-12 [12] questionnaires, validated for our country. The Womac was transformed to a 0–100 scale, so a higher value implies a better outcome.

Radiological evaluation was performed using standard standing anterior–posterior and lateral views. All postoperative radiographs were analyzed by independent experienced surgeons who did not know the names of the patients or their clinical evaluations. Radiographs at 6 postoperative weeks were compared with those at the last follow-up for alignment of the fracture and arthroplasty status. Radiographic osteopenia was evaluated subjectively and was considered only when it was evident. Notching was defined as greater than a 3 mm violation of the anterior cortex above the prosthesis. Healing fracture was defined as formation of bridging callus across the fracture site on each the anterior–posterior and lateral radiographic views, and nonunion as no evidence of sufficient callus 6 months after the fracture. A malalignment was defined [4] as varus/valgus of the distal fragment greater than 5º, flexion/extension greater than 10º, or shortening greater than 2 cm. The rotation was evaluated subjectively. Loosening of the arthroplasty was defined by continuous or progressive radiolucent lines or by migration of any component.

Statistical Analysis

Statistical analyses were conducted with SPSS software, version 15.0 (SPSS Inc., Chicago, USA). A *P*-value <0.05 was considered significant in all analysis. To determine normal distribution, a Kolmogorov–Smirnov test was used. For comparison between groups, we performed univariate analysis in categorical variables using chi-square test for parametric data or Mantel–Haenszel test for non-parametric data, and in continuous variables t-test or Mann–Whitney U-test. For comparison between pre-operative and post-operative data, the paired t-test or Wilcoxon signed-rank test was used. For analysis of risk factors associated to fracture, multivariate analysis was conducted using as independent variables those with univariate significant difference. Logistic regression model was used when the dependent variable was dichotomic, and Cox regression analysis when it was not. Kaplan–Meier test was used for cumulative survival analysis, and log-rank test to compare survival curves.

Results

No patients were lost to follow-up. In the fracture group, the mean follow-up after injury was 6.7 years (range, 5–9), and from the index TKA 13.4 years (range, 6–20). In the control group, the mean follow-up after TKA was 6.7 years (range, 5–9). Among published predisposing factors for periprosthetic fracture, the preinjury Knee Society scores and knee motion, or comorbidities were not significant ($P > 0.05$). The notching prevalence was similar in both groups ($P = 0.335$). All fractures occurred more than 3 cm above the flange of the femoral component. Presence of radiographic osteopenia was significantly related to periprosthetic fracture ($P = 0.034$), with an odds ratio for the fracture group of 1.7 (CI 95%, 1.1–2.8) and for control group of 0.4 (CI 95%, 0.1–1.0). No patients in both groups had received treatment for osteoporosis.

Fracture Results

In the fracture group, one patient developed a superficial wound infection that healed with debridement and antibiotics. There were no thromboembolism or neurovascular complications. In 25 (89.3%) fractures the mean time to achieve union was 12.4 weeks (range, 8–20). One nonunion was observed in a patient aged 56 at injury time who sustained an AO-33A3 fracture above an Axiom arthroplasty treated with dynamic condylar screw. At 7 months, the patient underwent implant removal and revision with a new dynamic condylar screw and autogenous bone graft, and union was noted 4 months later. Then, this patient underwent revision arthroplasty at 8 postinjury years for aseptic tibial loosening resulting with poor functional outcome at the last follow-up. In a second patient aged 65, with BMI of 33.8 and no osteopenia, who sustained an AO-33A1 fracture treated with locking condylar plate, a loss of plate fixation was observed at 4 postoperative months which required revision to a

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dynamic condylar screw. Union was observed 4 months later, resulting with stable arthroplasty and good functional outcome at the last follow-up. Another nonunion was observed in a third patient aged 74 who sustained an AO-33A2 fracture above an Axion arthroplasty that had been treated by revision index arthroplasty with cemented femoral component with long stem. This nonunion was not treated because it was well tolerated and because of cardiac problem. At 3 postinjury years, this patient showed an aseptic femoral and tibial loosening, ultimately treated with knee arthrodesis.

After union (Table 2), the coronal alignment of the fracture averaged 1.0º of varus (range, 8º of varus to 2º of valgus), being 3 fractures in varus > 5º (1 retrograde nail, and 2 dynamic condylar screws). The sagittal alignment averaged 1.0º of flexion of the distal fragment (range, 4º of flexion to 6º of extension). The mean shortening was 1.2 cm (range, 0.5–3.0) with a case >2 cm (retrograde nail). All patients, except one, with malalignment according to Rorabeck and Taylor [4] criteria had a knee flexion of at least 90º and good outcome at the last follow-up.

Arthroplasties Results

At the last follow-up, the mean femorotibial angle was similar in both groups (Table 2). In the fracture group, there were revision arthroplasties in the 2 aforementioned patients, one with knee arthrodesis at 3 postinjury years and other with aseptic tibial loosening at 8 postinjury years. In the control group, only one patient underwent revision of an index Duracon arthroplasty by aseptic tibial loosening at 8 postinjury years. To calculate TKA survival, the initial point was the date of the fracture in the group fractured, and endpoint the revision for any cause in both groups. The 7-year cumulative survival in the fracture group was 87.6 (CI 95%, 70–100) and in the control group 90.9 (CI 95%, 74–100). This difference was not significant ($P = 0.557$).

Functional Outcomes

In the fracture group, the mean knee scores at the last follow-up decreased significantly compared to the preinjury status ($P = 0.001$), while in the control group the scores improved significantly compared to the preoperative status ($P = 0.001$). At the last follow-up, the fracture group had significantly lower mean knee scores than the control group (Table 2). There was a significant difference in the range of knee motion between groups ($P = 0.005$). In the fracture group, there were 4 patients with flexion lower than 90º and 6 patients with loss of extension of at least 5º, while in the control group there was only patient with a loss of extension of 5º. In the fracture group, 22 (78.4%) patients were pain free, 4 (14.4%) suffered slight or occasional pain, and 2 (7.2%) moderate or continuous pain, while in the control group there were 26 (92.8%) pain free and 2 (7.2%) with slight or occasional pain ($P = 0.223$). In the fracture group, only 2 patients needed a cane before the fracture and at the last follow-up 4 (14,4%) patients required a cane and other patient 2 canes, while in the control group only one patient (3.5%) required a cane ($P = 0.345$). At the last follow-up, the health status and quality of life were significantly lower for the fracture group, except for pain, than in the control group (Table 2). In the fracture group, the mean Womac-pain decreased from 79.3 (range, 60–100) at preinjury time to 70.4 (range, 50–100) at the last follow-up ($P = 0.009$), the mean Womac-function from 78.4 (range, 50–100) to 68.7 (range, 43–90) ($P = 0.001$), the SF12-physical from 44.8 (range, 38–50) to 40.4 (range, 48–44) ($P = 0.032$), and the SF12-mental from 45.7 (range, 28–50) to 40.2 (range, 28–42) ($P = 0.037$).

Table 2
Postoperative Data.

	Fractured	Controls	*P*
Knee score[a]	83.1 (61–97; 9,0)	90.0 (70–99; 6.4)	0.002
Functional score[a]	80.7 (50–100; 10.7)	91.9 (65–100; 8.8)	0.002
Range of motion (º)	93.7 (75–110; 11.2)	102.6 (75–120; 11.6)	0.005
Womac pain	70.4 (40–90; 11.4)	77.3 (40–100; 15.3	0.061
Womac function	68,7 (43–90; 9.7)	77.5 (35–100; 15.7)	0.014
SF12 physical	40.4 (48–44; 7.3)	46.2 (26–50; 9.6)	0.013
SF12 mental	40.2 (28–42; 9.4)	45.8 (24–50; 10.3)	0.038
Notching	4	2	0.335
Femorotibial angle (valgus°)	5.8 (4–8; 1.0)	6.2 (4–10; 1.4)	0.251
Coronal alignment (°)[b]	−1.0 (−8 to +2; +2.2)		
Sagittal alignment (°)[b]	1.0 (−4 to +6; +1.7)		
Shortening (cm)	1.2 (0.5–3.0; 0.7)		

Data are presented as mean (range; standard deviation), unless otherwise stated.
[a] Knee Society scores.
[b] At fracture site. A negative value indicates varization (coronal plane) or flexion (sagittal plane).

Discussion

Varied risk factors for periprosthetic femoral fractures above TKA have been reported in the literature, such as female gender, advancing age, osteoporosis, rheumatoid arthritis, chronic steroid use and other conditions that result in osteopenia, and anterior notching of the femoral cortex [3]. As in the majority of studies [6,8], our cohort had a high mean age (75 years) and most of patients were women. These fractures are usually the result of low energy trauma in combination with an axial and torsional force [13]. Most of periprosthetic fractures in our study (78%) resulted after low-velocity falls from standing and were related to the presence of radiographic osteopenia. The role of notching of the anterior femoral cortex remains controversial. Two biomechanical studies found that notching of the anterior cortex was a risk factor for periprosthetic fracture above TKA because it decreased the bending and torsional strengths in the distal third of the femur [13,14], which was supported by some clinical studies [1,15]. However, in another study [16] of 1089 TKA, 30% of this series had notching but did not appear to pre-dispose to periprosthetic fracture.

The management of periprosthetic femoral fractures presents significant challenges to orthopedic surgeons. Internal fixation is currently the treatment of choice when the fracture is displaced and the prosthesis stable, but there is no consensus on the best surgical treatment for these fractures [3]. Modern implants, such as locking plates [8,15,17] or retrograde nails [5,7,18], are used in patients with poor bone quality, but they are not exempt from complications [6,19]. A systematic review [20] of 415 cases of periprosthetic fracture above knee arthroplasty reported a nonunion rate of 9%, fixation failure in 4%, an infection rate of 3% and revision surgery rate of 13%. To obtain a satisfactory patient outcome it has been stated that one needs to achieve fracture union, pain free range of knee movement from 0° to 90° with less than 2 cm of shortening, <5° varus/valgus, <10° deformity in the sagittal plane, and a return to pre-injury level of ambulation [4]. In our study, a relationship between malalignment of the fracture site and functional outcome was not found, probably because there were few cases with residual malalignment.

Periprosthetic distal femoral fracture is a serious complication in elderly patients, who often have associated comorbidities. In our study, only one patient aged 75 died 10 months after fracture. Other studies reported higher mortality, 26% within 6 postfracture months [17] and 33% within 1 postfracture year [7], but in these series the mean age was 81 years. Clinical outcome after conventional internal fixation of periprosthetic distal femur fractures in elderly patients was reported to be poor [1]. In our study, the patients with periprosthetic fracture had a significantly lower range of knee motion than those without fracture. In the fracture group there was a significant decrease in the range of knee motion at the last follow-up compared to the preinjury status, with 4 (14%) patients with flexion lower than 90º and 6 (21%) patients with loss of extension of at least 5º. The knee

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scores and motion significantly decreased from preinjury status to the last postoperative follow-up. With current implants, functional results reported in the literature are controversial. In the studies with a follow-up between 1 and 3 years, some found that the majority of the patients returned to the level of activity that they had had before the fracture with no variations of the functional status or the autonomy [21–23], while others found a relevant decrease of knee function and severe limitations in gait and activities of daily living in 32%–75% of the patients [24,25]. Hernigou et al [25] reviewed the results of 20 periprosthetic femoral fractures treated by nonoperative and operative methods and found a significant decrease of the functional outcomes in the majority of the patients. At mean follow-up of 2 years, the mean knee flexion decreased from 105º to 91º, the knee score from 78 to 56, and the functional score from 72 to 54. A cane was needed for 10 patients, two canes for 3 patients, and a walker for 2 patients. Healy et al [21] reported on 20 periprosthetic femoral fractures above total knee prostheses treated with internal fixation and followed a mean of 2.2 years. They reported that all the patients returned to the preinjury level and there were no modifications of the Knee Society scores, which averaged from 85 to 84 for knee score and from 55 to 57 for functional score. Hoffmann et al [15] reported on 31 fractures treated with locking plates and followed a mean of 1.8 years. They reported that two-thirds of the patients required long-term ambulatory aid assistance, 23% had moderate or continuous pain, the final knee flexion was decreased, 44% of patients had a knee flexion lower than 90° and the 14% had a loss of extension of at least 5°. Large et al [26] referred good final results in 39 fractures treated with locking plates and followed a mean of 3.4 years. There were 6 patients with knee flexion lower than 90°, 4 patients had a loss of extension of 5° and other 3 a loss of extension between 10° and 20°, with a final range of knee motion of 81°–101°. Kolb et al [23] reported on 19 fractures treated with locking plates and followed a mean of 3.8 years. They found that all the patients except one regained their prefracture ambulatory status. Four patients required one cane, 2 needed two canes, and one required a walker. The mean ROM was 97°, the mean knee score was 78, and the mean functional score was 54.

With regard to health status and quality of life, the SF12 and Womac scores significantly were decreased from preinjury status to the last postoperative follow-up. Chen et al [27], in a review of literature, interestingly found patient satisfaction rates of 68% for nonoperative and 70% for operative treatment after periprosthetic fractures above TKA. Raab et al [28] reviewed the results of 11 patients with mean age of 65 years treated by locking plates and followed a mean of 1 year. They found that all patients have achieved at least 80° of flexion with an average range of motion from 4° to 92°, but many patients had a limited functional outcome related to other medical conditions, poor function before the injury, and persistent pain. In the prospective study by Ricci et al [8], among the 17 patients who healed their fracture, 6 required additional ambulatory support compared with baseline. Gliatis et al [5] reported on 10 fractures treated with retrograde nail and followed a mean of 2.8 years. They found a trend towards lower scores Womac, but the differences before and after surgery were not significant. The functional score ranged from 20 to 25, and the pain score from 5 to 7.

A limitation of our study is the relatively small sample size. Another limitation is that patients included in control group were not consecutive because of the matched design of the study, which might decrease the clinical significance. The strengths are its prospective comparative design and, to our knowledge, the follow-up in our study was longer than the other available reports. The current study found that internal fixation of a distal periprosthetic femur fracture in patients with TKA is associated with an impairment of the knee function and quality of life, but the arthroplasty complication and survival rates are similar to those patients with no fracture.

References

1. Figgie MP, Goldberg VM, Figgie III HE, et al. The results of treatment of supracondylar fracture above total knee arthroplasty. J Arthroplasty 1990;5:267.
2. Bhattacharyya T, Chang D, Meigs JB, et al. Mortality after periprosthetic fracture of the femur. J Bone Joint Surg Am 2007;89:2658.
3. Parvizi J, Jain N, Schmidt AH. Periprosthetic knee fractures. J Orthop Trauma 2008;22:663.
4. Rorabeck CH, Taylor JW. Periprosthetic fractures of the femur complicating total knee arthroplasty. Orthop Clin North Am 1999;30:265.
5. Gliatis J, Megas P, Panagiotopoulos E, et al. Midterm results of treatment with a retrograde nail for supracondylar periprosthetic fractures of the femur following total knee arthroplasty. J Orthop Trauma 2005;19:164.
6. Ebraheim NA, Liu J, Hashmi SZ, et al. High complication rate in locking plate fixation of lower periprosthetic distal femur fractures in patients with total knee arthroplasties. J Arthroplasty 2012;27:809.
7. Ehlinger M, Adam P, Abane L, et al. Treatment of periprosthetic femoral fractures of the knee. Knee Surg Sports Traumatol Arthrosc 2011;19:1473.
8. Ricci WM, Loftus T, Cox C, et al. Locked plates combined with minimally invasive insertion technique for the treatment of periprosthetic supracondylar femur fractures above a total knee arthroplasty. J Orthop Trauma 2006;20:190.
9. Müller ME, Nazarian S, Koch P. Classification AO des fractures. Berlin: Springer-Verlag; 1987. p. 138.
10. Insall JN, Dorr LD, Scott RD, et al. Rationale of the Knee Society clinical rating system. Clin Orthop Relat Res 1989;248:13.
11. Batlle-Gualda E, Esteve-Vives J, Piera MC, et al. Adaptación transcultural del cuestionario WOMAC específico para artrosis de rodilla y cadera. Rev Esp Reumatol 1999;26:38.
12. Alonso J, Prieto L, Anto JM. La versión española del SF-36 Health Survey (Cuestionario de Salud SF-36): un instrumento para la medida de los resultados clínicos. Med Clin (Barc) 1995;104:771.
13. Shawen SB, Belmont PJ, Klemme WR, et al. Anterior femoral notching in periprosthetic supracondylar femoral fractures: a biomechanical analysis. J Bone Joint Surg Am 2003;85:115.
14. Lesh ML, Schneider DJ, Deol G, et al. The consequences of anterior femoral notching in total knee arthroplasty: a biomechanical study. J Bone Joint Surg Am 2000;82:1096.
15. Hoffman MF, Jones CB, Sietsema DL, et al. Outcome of periprosthetic distal femoral fractures following knee arthroplasty. Injury 2012;43:1084.
16. Ritter MA, Thong AE, Keating EM, et al. The effect of femoral notching during total knee arthroplasty on the prevalence of postoperative femoral fractures and on clinical outcome. J Bone Joint Surg Am 2005;87:2411.
17. Hou Z, Bowen TR, Irgit K, et al. Locked plating of periprosthetic femur fractures above total knee arthroplasty. J Orthop Trauma 2012;26:427.
18. Chettiar K, Jackson MP, Brewin J, et al. Supracondylar periprosthetic femoral fractures following total knee arthroplasty: treatment with a retrograde intramedullary nail. Int Orthop 2009;33:981.
19. Streubel PN, Gardner MJ, Morshed S, et al. Are extreme distal periprosthetic supracondylar fractures of the femur too distal to fix using a lateral locked plate? J Bone Joint Surg Br 2010;92:527.
20. Herrera DA, Kregor PJ, Cole PA, et al. Treatment of acute distal femur fractures above a total knee arthroplasty: systematic review of 415 cases (1981–2006). Acta Orthop 2008;79:22.
21. Healy WL, Sliski JM, Incavo SJ. Operative treatment of distal femoral fractures proximal to total knee replacements. J Bone Joint Surg Am 1993;75:27.
22. Bezwada HP, Neubauer P, Baker J, et al. Periprosthetic supracondylar femur fractures following total knee arthroplasty. J Arthroplasty 2004;19:453.
23. Kolb W, Guhlmann H, Windisch C, et al. Fixation of periprosthetic femur fractures above total knee arthroplasty with the less invasive stabilization system: a midterm follow-up study. J Trauma 2010;69:670.
24. Platzer P, Schuster R, Adrian S, et al. Management and outcome of periprosthetic fractures after total knee arthroplasty. J Trauma 2010;68:1464.
25. Hernigou P, Poignard A, Manicom O, et al. Traitement des fractures du fémur distal sur prothèse totale de genou. Rev Chir Orthop 2006;92:148.
26. Large TM, Kellam JF, Bosse MJ, et al. Locked plating of supracondylar periprosthetic femur fractures. J Arthroplasty 2008;23(Suppl 1):115.
27. Chen F, Mont MA, Bachner RS. Management of ipsilateral supracondylar femur fractures following total knee arthroplasty. J Arthroplasty 1994;9:521.
28. Raab GE, Davis III CM. Early healing with locked condylar plating of periprosthetic fractures around the knee. J Arthroplasty 2005;20:984.

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