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ORIGINAL ARTICLE

# Does Prior Infection Alter the Outcome of TKA After Tibial Plateau Fracture?

**A. Noelle Larson MD, Arlen D. Hanssen MD, Joseph R. Cass MD**

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**Abstract** Total knee arthroplasty performed after tibial plateau fracture has a known high rate of complications. We hypothesized TKAs performed after infected tibial plateau fractures would have an even higher complication rate when compared with noninfected tibial plateau fractures. In a matched case-control study, we retrospectively reviewed 19 patients who underwent primary TKAs after infected tibial plateau fractures between 1971 and 2005. The mean time from the most recent infection to arthroplasty was 5.6 years. The minimum clinical followup after TKA was 2 years (mean, 6.4 years; range, 2–15.1 years). Case patients were matched for age, gender, and arthroplasty year with 19 control subjects who underwent TKAs for tibial plateau fractures with no history of infections. After surgery, the Knee Society scores for the study group improved from 45 to 63 for pain and from 37 to 63 for function. Ten case patients (53%) sustained complications, including surgery for wound breakdown (three), manipulation (one), aseptic loosening (two), definitive resection arthroplasty (two), and above-knee amputation (two). Recurrent infections occurred in five patients (26%) at a mean of 1.1 years. Previously infected knees were 4.1 times more likely to require additional procedures compared with knees with no previous infection.

**Level of Evidence:** Level III, therapeutic study. See the Guidelines for Authors for a complete description of levels of evidence.

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Each author certifies that his or her institution has approved the human protocol for this investigation and that all investigations were conducted in conformity with ethical principles of research.

A. N. Larson, A. D. Hanssen, J. R. Cass (✉)
Department of Orthopedic Surgery, Mayo Clinic,
200 First Street SW, Rochester, MN 55905, USA
e-mail: Cass.joseph@mayo.edu

## Introduction

Posttraumatic arthritis from a previous tibial plateau fracture is an indication for TKA. Published reports show a high rate of complications in patients with previous tibial plateau fractures treated with TKA, including deep infections, wound breakdown, extensor mechanism disruption, aseptic loosening, and postoperative stiffness [8, 11, 12]. The etiology of these poor outcomes is likely multifactorial and includes younger patient age, bony deficiency, soft tissue compromise, posttraumatic stiffness, and previous occult infection.

In the initial treatment of tibial plateau fractures, infection is a devastating yet common complication. From 6% to 28% of operatively treated tibial plateau fractures reportedly have infection develop [10, 13]. However, there has been no published discussion regarding the outcomes of patients with infected tibial plateau fractures who subsequently require TKA as a result of posttraumatic arthritis.

We hypothesized patients with previous infections would have more postoperative complications and more recurrent infections, shorter joint survival time, and poorer Knee Society scores compared with control subjects with previous tibial plateau fractures but no history of infections.

## Materials and Methods

For a retrospective matched case-control study, we searched our institutional computerized database to identify all patients with a history of an infected tibial plateau fracture who underwent primary TKA between January 1, 1971, and December 31, 2005. During the study period, 26,077 primary TKAs were performed at our institution. We included all patients with a history of tibial plateau fracture and subsequent treatment complicated by deep infection. All primary TKAs were performed at a large referral center, but initial treatment of the fracture often was performed at an outside facility. We excluded patients with extraarticular fracture patterns or fractures complicated only by superficial infection. Nineteen patients (19 knees) met our study criteria. During the study period, 447 patients with the previous diagnosis of tibial fracture (any type) with no history of infection underwent primary TKA. From this population, we selected control subjects who had a previous tibial plateau fracture and matched them with the 19 case patients by age, gender, and year of TKA. The mean age at the time of TKA was 58 years (range, 28–75 years) (Table 1). The mean body mass index was 32.1 kg/m$^2$ (range, 20.5–40.3 kg/m$^2$). Ten patients were female and nine were male. The mean time from initial injury to TKA was 6.5 years (range, 6 months–40 years). The mean time from the most recent infection to TKA was 5.6 years (range, 2 months–39 years). In five patients, there was less than 1 year from the time of the most recent infection until TKA. Several patients had medical comorbidities, including diabetes mellitus (three), peripheral vascular disease (one), and chronic skin dermatitis (one). Demographics between the control and case groups were similar (Table 1). The minimum followup after TKA was 2 years (mean, 6.4 years; range, 2–15.1 years). We obtained Institutional Review Board approval before initiation of the study.

Three fractures were open, and the remainder were closed (Table 2). We graded all fractures using the classification of Gustilo and Anderson [3]. One open fracture was a Gustilo and Anderson Grade IIIB, one was Grade IIIC, and one was of unknown grade. Two of the patients with open injuries required medial gastrocnemius flaps for wound closure at the time of injury. One other patient with a closed injury required a medial gastrocnemius flap for coverage after open reduction, and internal fixation was complicated by deep infection.

**Table 1.** Demographic comparison of case patients and control subjects

| Variable | Case patients | Control subjects |
|---|---|---|
| Number of patients | 19 | 19 |
| Mean age at TKA (years) | 58 (28–75) | 58 (29–75) |
| Gender (male/female) | 9/10 | 9/10 |
| Nonoperative treatment | 3 | 3 |
| Two-stage TKA | 5 | 0 |
| Antibiotics in cemented TKA | 13 | 9 |
| Time to followup after TKA (years) | 6.4 | 8.3 |

Fracture patterns were assessed using the classification of Schatzker et al. [9]. Cases included four Grade II fractures, three Grade IV fractures, and three Grade VI fractures. In the remainder of the knees, the fracture pattern was unknown, because injury radiographs were not available for review.

Three fractures were treated nonoperatively with closed reduction and the remainder were treated with open reduction and internal fixation. In the nonoperative cases, infections developed from skin breakdown resulting from cast complications, whereas in the remaining cases, infections developed after operative fixation of the fracture.

An organism was isolated in 11 of the 19 patients at the time of the initial infection, including Staphylococcus epidermidis in five patients and Staphylococcus aureus in two patients (one methicillin-resistant and one with sensitivities unknown). There additionally was one case each of Bacilli species, Streptococcus pyogenes, Peptostreptococcus, and Propionibacterium. Several patients presented with mixed flora, including Escherichia coli, Streptococcus viridans, and Alternaria from an open fracture. All patients with positive culture specimens were treated with intravenous antibiotics, except for the patient with culture specimens positive for Propionibacterium, which was considered a contaminant.

All patients were evaluated clinically for the presence of active infection before TKA (Table 3). All hardware from fracture fixation was removed during a separate procedure before TKA. In 14 patients, various methods were used to exclude infection before TKA, including inflammatory markers (nine patients), intraoperative pathology report (nine), preoperative bone scans or indium-labeled leukocyte scans (five), and preoperative culture results (five). Two patients had positive infection screenings and were treated with a two-stage procedure. The remaining five patients underwent TKAs in the 1970s and 1980s and had inadequate preoperative infection screening. Infection was excluded in these patients based only on clinical examination findings. We considered our final results with and without this cohort.

Six patients (six knees) with a recent history of infection were treated with two-stage TKA. The first procedure entailed cultures, débridement of the knee, bone cuts, and placement of an antibiotic-impregnated cement spacer. Total knee implants were placed at the second procedure, typically after a course of intravenous antibiotics if culture results were positive. The mean time between the staged procedures was 61 days (range, 6–134 days). Of the six patients (six knees) treated with two-stage TKAs, three had

**Table 2.** Summary of complications in this case series

| Patient | Age (years) | Year of TKA | Open fracture | Treatment | Antibiotic-impregnated cement | Two-stage TKA | Any TKA complication | Superficial infection | Recurrent deep infection | Manipulation | Aseptic loosening |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 58 | 1971 | No | CR | No | No | Revision | No | No | Yes | Yes |
| 2 | 59 | 1973 | No | ORIF | No | No | AKA | No | Yes | No | No |
| 3 | 65 | 1973 | No | ORIF | No | No | Yes | No | No | Yes | No |
| 4 | 65 | 1981 | No | ORIF | No | No | Yes | No | Yes | Yes | No |
| 5 | 28 | 1983 | No | ORIF | No | No | Yes | No | No | No | Yes |
| 6 | 59 | 1989 | No | ORIF | Yes | No | No | No | No | No | No |
| 7 | 75 | 1992 | No | CR | Yes | No | No | No | No | No | No |
| 8 | 69 | 1993 | No | ORIF | Yes | No | Yes | Yes, flap | No | No | No |
| 9 | 67 | 1996 | No | ORIF | Yes | No | No | No | No | No | No |
| 10 | 68 | 1997 | No | ORIF | No | No | No | No | No | No | No |
| 11 | 49 | 1998 | No | ORIF | Yes | No | Resection | No | Yes | Yes | No |
| 12 | 73 | 2000 | No | ORIF | Yes | No | Peroneal nerve palsy | Yes | No | No | No |
| 13 | 45 | 2001 | No | ORIF | Yes | Yes | No | No | No | No | No |
| 14 | 53 | 2001 | No | ORIF, external fixation | Yes | Yes | Resection | No | Yes | Yes | No |
| 15 | 49 | 2002 | Yes | ORIF | Yes | No | No | No | No | No | No |
| 16 | 60 | 2004 | Yes | ORIF | Yes | Yes | AKA | No | Yes | Yes | No |
| 17 | 59 | 2005 | Yes | CR | Yes | Yes | No | No | No | No | No |
| 18 | 56 | 2005 | No | ORIF | Yes | Yes | No | No | No | No | No |
| 19 | 50 | 2005 | No | ORIF | Yes | Yes | No | No | No | No | No |

CR = closed reduction; ORIF = open reduction and internal fixation; AKA = above-knee amputation.

**Table 3.** Summary of preoperative screening for infection

| Patient | Year of TKA | Preoperative blood tests | Preoperative indium scan | Preoperative aspiration | Cultures at first of two-stage TKA | Intraoperative cultures at TKA | Intraoperative pathology |
|---|---|---|---|---|---|---|---|
| 1 | 1971 | | | | | No growth | |
| 2 | 1973 | | | | | NA | |
| 3 | 1973 | | | | | NA | |
| 4 | 1981 | | | | | NA | |
| 5 | 1983 | | | | | NA | |
| 6 | 1989 | | Negative | | | No growth | |
| 7 | 1992 | | Negative | No growth | | NA | |
| 8 | 1993 | | Negative | | | No growth | WNL |
| 9 | 1996 | WNL | Negative | | | No growth | WNL |
| 10 | 1997 | | | No growth | | NA | |
| 11 | 1998 | | | | | NA | WNL |
| 12 | 2000 | WNL | Negative | | | NA | |
| 13 | 2001 | WNL | | | No growth | NA | WNL |
| 14 | 2001 | WNL | | | No growth (cephalexin) | No growth | WNL |
| 15 | 2002 | WNL | | | | No growth | |
| 16 | 2004 | WNL | | | No growth. | NA | WNL |
| 17 | 2005 | WNL | | | Yes, MRSA (vancomycin) | No growth | WNL |
| 18 | 2005 | WNL | | Yes, MRSE | No growth (vancomycin) | No growth | WNL |
| 19 | 2005 | WNL | | | Prop (cephalexin) | No growth | WNL |

WNL = within normal limits; MRSE = methicillin-resistant Staphylococcus epidermidis; MRSA = methicillin-resistant Staphylococcus aureus; Prop = Propionibacterium; NA = not available.

no growth from culture specimens taken at the time of resection arthroplasty. Two of the three underwent primary TKAs once 5-day culture results were available. The third patient was treated prophylactically with oral cephalexin for 1 month. The remaining three patients had positive cultures at the time of débridement. Culture specimen of one patient grew Propionibacterium, as noted previously, and this patient was treated with 4 weeks of oral cephalexin as a precaution. Culture specimens from two patients grew methicillin-resistant S. aureus or S. epidermidis and these patients were treated with a 6-week course of intravenous vancomycin before implant placement.

The 13 patients scheduled for one-stage TKA consented preoperatively to abort the TKA should gross infection be encountered during surgery. All 13 patients underwent TKAs as planned. Intraoperative culture specimens were obtained during primary TKAs in nine patients, all of which revealed no growth. In nine cases, intraoperative specimens were sent to pathology and no acute inflammation was found.

Four of the five patients were treated with two-stage TKAs with placement of an antibiotic spacer as outlined previously. In one case, the patient underwent hardware removal, débridement, and intravenous antibiotic therapy 3 months before TKA, although bone cuts were not performed and antibiotic spacers were not placed. Three patients had tibial stems only, five patients had femoral and tibial stems, and two patients had tibial augments.

Antibiotic-impregnated cement was used in the majority of patients at the time of TKA (11 patients). After 1988, antibiotic-impregnated cement was used in all cases for implant fixation, with one exception because of surgeon preference (Patient 10).

We retrospectively reviewed charts for demographic data. Date of initial injury, type of treatment, documentation of prior infection, and causative organism were noted. We reviewed preoperative and followup radiographs. Preoperative and postoperative pain, function, range of motion, and knee stability were recorded. We calculated scores for pain and function using the Knee Society scoring system for all case patients and control subjects before TKA and at the latest followup [5]. One patient in the study group died from independent causes before 2-year outcome scores could be collected, and one patient in the control group was lost to followup 1.1 years postoperatively. These patients were removed from the analysis of Knee Society scores.

We used matched-pairs analysis to compare preoperative and postoperative Knee Society scores. Student's two-tailed t test was used to assess results between case patients and control subjects. We performed a Cox proportional-hazard regression analysis to compare the case patients and control subjects and to generate a hazard ratio. A Kaplan-Meier analysis was used to assess time to joint failure and time to recurrent infection, and a log rank test was used to compare results between the case and control groups.

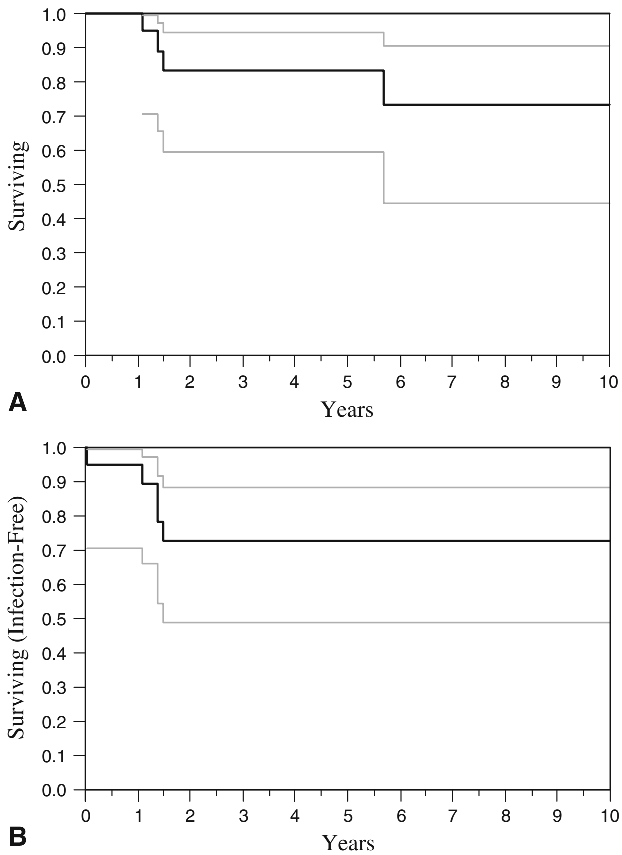


**Fig. 1A–B** Kaplan-Meier survival curves show survival of the (**A**) implant overall and (**B**) infection-free survival in the case group. The gray lines indicate 95% confidence intervals.

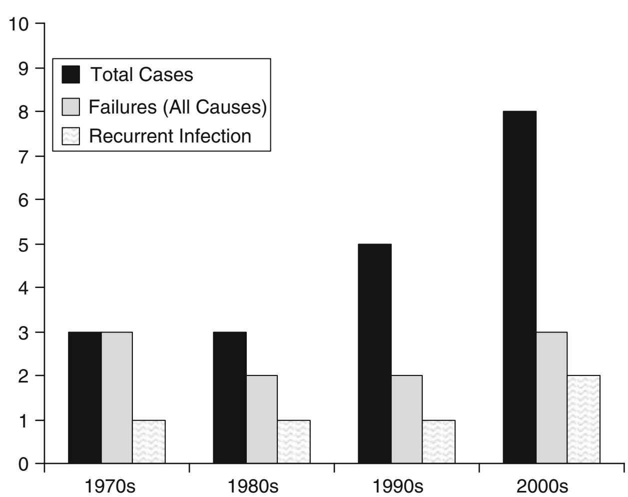


**Fig. 2** The number of patients undergoing TKA with a history of infected tibial plateau fracture is shown by decade. Patients with subsequent complications are shown by the gray bars and patients with recurrent infections by the hatched bars.

## Results

Previously infected knees were 4.1 times more likely ($p = 0.02$) to require additional procedures for complications compared with knees with no previous infection (95% confidence interval, 1.2–18.3). The case group experienced numerous complications after TKA (Table 2). Nine patients have had no recurrent infection and no additional surgery since the time of TKA. Eight of these nine patients had antibiotics placed in the cement at the time of TKA, and four of the nine underwent two-stage primary TKA. Thus, four of the six patients undergoing two-stage TKA had no additional evidence of infection at the most recent followup. Ten patients had complications after TKA, including five aseptic complications and five recurrent infections. Excluding the five patients with inadequate preoperative infection screening by current standards, only six of the 14 patients (43%) had complications develop after TKA, including five recurrent infections and one case of aseptic loosening. In contrast, the control group did quite well after TKA after noninfected tibial plateau fractures. Three of the 19 patients required manipulation after TKA. At a mean of 8.3 years since primary TKA, no patients required revision surgery or had an infection develop.

Five-year implant survival for all causes was greater ($p = 0.003$) in the control group than in the case group (100% versus 84% ± 9%, respectively) (Fig. 1). The 5-year infection-free survival was 73% ± 10% in the case group compared with 100% in the control group ($p = 0.023$). An analysis of failures by decade reveals lower rates of recurrent infection in recent decades (Fig. 2).

Knee Society pain score improvement was greater ($p = 0.002$) in the control group than in the case group, but the change in the functional score between the two groups was similar (Fig. 3). Knee Society scores improved in the study patients from 45 to 63 for pain ($p = 0.001$)

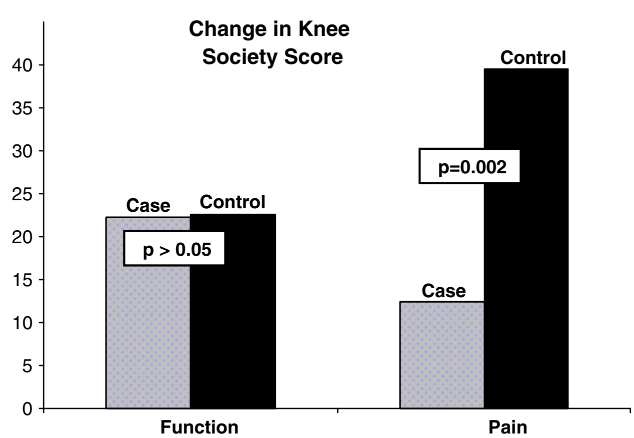


**Fig. 3** The change in Knee Society score after TKA is shown. Case group patients had only a modest improvement in pain scores compared with control subjects.

and from 37 to 63 for function ($p < 0.0001$). In the control group, Knee Society scores improved from 44 to 84 for pain ($p < 0.0001$) and from 43 to 66 for function ($p = 0.008$).

## Discussion

TKA performed after tibial plateau fracture has a known high rate of complications although the specific fate of patients with TKAs with previously infected tibial plateau fractures is less clear. Thus, we aimed to describe and contrast the complications and outcomes in this patient population compared with matched control subjects with previous tibial plateau fractures but no history of infections.

The limitations of this study include a small number of patients in the case and control groups. Given the limited numbers of patients, we could control only for age of patient, date of TKA, and gender and, therefore, were unable to control for medical comorbidities. Additionally, this is a retrospective study with limited patient followup. One patient was lost to followup in each of the control and case groups. TKA after an infected tibial plateau fracture is rare. Practitioners and patients should be aware of the associated high complication rate and compromised outcomes.

Compared with matched control subjects, patients in our series with a previous infected tibial plateau fracture were four times more likely to have a complication requiring additional surgery. In addition, patients with a previous infection had more postoperative complications, more recurrent infections, and shorter joint survival time. The Knee Society function score was similar in both groups. However, Knee Society pain scores in the case group lagged behind those of the control subjects.

It has been established that patients with previous tibial plateau fractures undergoing TKAs have high complication rates. In one series of 15 TKAs performed after tibial plateau fractures, three patients had deep infections develop, two patients experienced patellar tendon ruptures, and three patients required manipulation under anesthesia for stiffness [8]. From a report of 62 patients, 26% had complications, including superficial infection/wound breakdown (five), deep infection (two), component revision (five), manipulation (five), and extensor mechanism disruption (five) [12].

Despite careful efforts to eliminate infection, we found a very high rate of complications after TKA in patients with a history of an infected tibial plateau fracture. Two-stage exchange for treatment of an infected joint arthroplasty has been described [1, 2], and one study showed the usefulness of antibiotic-impregnated cement in primary TKA after joint sepsis [6]. In our small series, however, antibiotic-impregnated cement or two-stage TKA did not demonstrably reduce recurrent infection perhaps owing to inadequate power. Until additional data are available, we continue to use antibiotic-impregnated cement in all TKAs after tibial plateau fractures. In patients at high-risk with less than 1 year since active evidence of infection, we perform two-stage TKA with antibiotic therapy and a 4- to 6-week delay between procedures.

We also noted a high rate of amputations and resection arthroplasties in this patient population (21%). As a result of considerable bone loss from the initial traumatic insult, patients undergoing primary TKA for posttraumatic arthritis often require augments or stemmed implants and may have greater bone loss at presentation compared with patients with osteoarthritis [12]. In the case of a recurrent infection, preexisting bone loss may limit the ability to perform successful two-stage resection arthroplasty, bony débridement, and reimplantation. Furthermore, with substantial bone loss, patients no longer may be candidates for fusion. The only knee arthrodesis attempted in our series failed owing to recurrent infection. Bone loss in conjunction with persistent infection threatens future attempts at limb salvage and may necessitate amputation.

When patients with inadequate preoperative infection screening are removed from our cohort, the complication rate decreases from 53% to 43%. Again, our cohort size is too small to show statistically significant benefit from these screening techniques. Given the high risk of recurrent infections in this patient population, however, our center has instituted careful preoperative screening before implant placement in patients with a history of infection. This includes knee aspiration using a sterile technique, measurement of inflammatory indices (C-reactive protein and erythrocyte sedimentation rate), and, in some cases, indium-labeled leukocyte scans. When any of the above studies shows evidence of ongoing infection, two-stage primary TKA is performed with the alternative of delaying TKA until infection indices normalize and/or greater than 1 year after known infection.

Our data highlight the importance of avoiding infection at the time of primary fracture treatment. Appropriate staging of the procedures and careful intraoperative handling of the tissues should be done to minimize the risk of infection. Newer locking implants that require less stripping of the soft tissues may result in lower infection rates; however, early studies still suggest high complication rates [4, 7]. To reduce infection risks, nonoperative treatment can be considered in elderly patients with stable fracture patterns, with delayed TKA if the patient is symptomatic after fracture healing.

We found a high rate of complications after TKA after an infected tibial plateau fracture. The surgeon and patient should be prepared for a high risk of recurrent infection and lower pain scores compared with patients with no history of infection. Preoperative screening, antibiotic-impregnated cement, and, in certain cases, two-stage primary TKA are promising tools to decrease the risk of recurrent infection, although further research is needed to elucidate the value of these added precautions.

## References


1. Burnett RS, Kelly MA, Hanssen AD, Barrack RL. Technique and timing of two-stage exchange for infection in TKA. *Clin Orthop Relat Res.* 2007;464:164–178.
2. Garvin KL, Hanssen AD. Infection after total hip arthroplasty: past, present, and future. *J Bone Joint Surg Am.* 1995;77:1576–1588.
3. Gustilo RB, Anderson JT. Prevention of infection in the treatment of one thousand and twenty-five open fractures of long bones: retrospective and prospective analyses. *J Bone Joint Surg Am.* 1976;58:453–458.
4. Haidukewych G, Sems SA, Huebner D, Horwitz D, Levy B. Results of polyaxial locked-plate fixation of periarticular fractures of the knee. *J Bone Joint Surg Am.* 2007;89:614–620.
5. Insall JN, Dorr LD, Scott RD, Scott WN. Rationale of the Knee Society clinical rating system. *Clin Orthop Relat Res.* 1989;248:13–14.
6. Lee GC, Pagnano MW, Hanssen AD. Total knee arthroplasty after prior bone or joint sepsis about the knee. *Clin Orthop Relat Res.* 2002;404:226–231.
7. Phisitkul P, McKinley TO, Nepola JV, Marsh JL. Complications of locking plate fixation in complex proximal tibia injuries. *J Orthop Trauma.* 2007;21:83–91.
8. Saleh KJ, Sherman P, Katkin P, Windsor R, Haas S, Laskin R, Sculco T. Total knee arthroplasty after open reduction and internal fixation of fractures of the tibial plateau: a minimum five-year follow-up study. *J Bone Joint Surg Am.* 2001;83:1144–1148.
9. Schatzker J, McBroom R, Bruce D. The tibial plateau fracture: the Toronto experience 1968–1975. *Clin Orthop Relat Res.* 1979;138:94–104.
10. Stannard JP, Wilson TC, Volgas DA, Alonso JE. The less invasive stabilization system in the treatment of complex fractures of the tibial plateau: short-term results. *J Orthop Trauma.* 2004;18:552–558.
11. Weiss NG, Parvizi J, Hanssen AD, Trousdale RT, Lewallen DG. Total knee arthroplasty in post-traumatic arthrosis of the knee. *J Arthroplasty.* 2003;18(3 suppl 1):23–26.
12. Weiss NG, Parvizi J, Trousdale RT, Bryce RD, Lewallen DG. Total knee arthroplasty in patients with a prior fracture of the tibial plateau. *J Bone Joint Surg Am.* 2003;85:218–221.
13. Young MJ, Barrack RL. Complications of internal fixation of tibial plateau fractures. *Orthop Rev.* 1994;23:149–154.