Clinical/Basic Science Research Article

OPEN

High rate of complications after operative fixation of open periprosthetic distal femur fractures

Yu Min Suh, MD[a,*], Robert Bardsley, BS[a], John Hwang, MD[b], Zachary Sirois, MD[b], Arun Aneja, MD[c], Jeffrey A. Foster, MD[c], J. R. Goetz, BS[c], Daria Kinchelow, BS[c], Chandler Sneed, BS[c], Shawn Dripchak, BS[c], Eric Swart, MD[d], John Garfi, MD[d], Brad Askam, MD[e], Brian Richard, MD[e], Yohan Jang, DO, FAAOS[f], Jon Luc Poirier, BA[f], Luke Lopas, MD[g], Christian Pean, MD[h], JaNell Dupree, BS[h], Mikhail Bethell, BS[h], Lulla Kiwinda, BS[h], Matthew Brown, MD[h], Judith Siegel, MD[a], Andrew Chen, MD[a]

Abstract

Introduction: The rate of open distal periprosthetic femur fractures is rising because of the aging population and increase in the frequency of total knee arthroplasties. Operative fixation of these complex injuries is often challenging. Multiple studies have evaluated outcomes of closed distal femur fractures, but outcomes after open injuries are unclear.

Materials and Methods: This is a multicenter retrospective case series of open periprosthetic distal femur fractures that were treated with open reduction and internal fixation at 7 institutions over a 10-year period. Standard demographic, injury, and operative data were collected. Charts were evaluated for complications including implant failure, deep infection, nonunion, malunion, and unplanned return to the operating room.

Results: Twenty-one patients were included with a mean age of 72.3 years. The mean postoperative follow-up was 23.8 months (4.2–105.5 months). Gustilo-Anderson fracture classification ranged as per the following: Type I (9), Type II (6), Type IIIA (5), and Type IIIB (1). Six patients were initially placed in an external fixator. Definitive fixation was either with an intramedullary nail (28.6%) or locked plating (71.4%). Eleven patients (52.4%) had at least 1 complication. All required return to the operating room at least once. Eight patients had a nonunion, 4 of which were septic and the other 4 aseptic. Two patients had a deep infection not involving a nonunion. Four patients were placed on lifelong suppressive antibiotics. The average time to union was 20.4 ± 14.1 months.

Discussion: This multicenter case series highlights the difficulty of treating open periprosthetic distal femur fractures as evidenced by the high complication rate (specifically nonunion and infection).

Keywords: periprosthetic, fracture, open, complications, infections, nonunion, distal, femur

1. Introduction

Periprosthetic femur fracture is a serious complication after total knee arthroplasty (TKA), most commonly presenting as fragility fractures associated with trauma[1–4] in the supracondylar region of the distal femur.[5] The increase in the number of total knee arthroplasties performed in the past decade has also led to a concurrent rise in periprosthetic distal femur fractures.[6,7] Periprosthetic fracture is the third most common complication after TKA with rates of 0.3%–5.5% in the first 4 years after the initial procedure,[8–11] and the need for primary TKA is projected to increase to 673% from 2005 to 2030.[12]

The standard of care for patients with these injuries is operative intervention. Treatment options can be divided into 2 main categories: open reduction and internal fixation (ORIF) and arthroplasty. The former range from implants such as single locked plates, intramedullary nail (IMN), nail-plate combination constructs, or dual plating (use of medial and lateral plates). Arthroplasty options include revision TKA as well as distal femoral replacement.[13]

Fracture fixation is challenging and depends on a multiple factors including patient's age, comorbidities, displacement, fracture location, remaining bone stock and quality, and stability of the implant.[14] In the setting of an intact and stable femoral component, ORIF is usually the treatment of choice, whether by plating and/or IMN, as patients have been shown to have higher functional outcomes compared with distal femoral replacement

The authors have no sources of funding to disclose. There is no conflict of interest for all authors listed.

[a] Department of Orthopaedic Surgery, University of North Carolina, Chapel Hill, NC, [b] Department of Orthopedics, Mount Carmel Health System, Columbus, OH, [c] Orthopaedic Surgery & Sports Medicine, University of Kentucky, Lexington, KY, [d] Orthopaedic Surgery at Lahey Hospital and Medical Center, Burlington, MA, [e] Department of Orthopaedic Surgery, University of Arizona, Tucson, AZ, [f] Department of Orthopaedic Surgery, Indiana University Health, Indianapolis, IN, [g] Department of Orthopaedic Surgery, Eskenazi Hospital, Indianapolis, IN, [h] Department of Orthopaedic Surgery, Duke University, Durham, NC.

** Corresponding author. Address: UNC Department of Orthopaedics, 130 Mason Farm Rd, Chapel Hill, NC 27599. E-mail address: YuMin.Suh@unchealth.unc.edu (Y. M. Suh).*

OTAI (2025) e400

Received: 4 February 2024 / Received in final form: 14 January 2025 / Accepted: 3 March 2025
Published online 23 April 2025

http://dx.doi.org/10.1097/OI9.0000000000000400

or revision arthroplasty as the initial surgical treatment.[13] Recent systematic reviews from Rinehart et al and Dunbar et al concluded that plate and IMN fixation produced similar functional outcomes.[15,16] Another review by Shah et al[11] demonstrated similar average union rates and time to union between intramedullary nail and locked plate fixation for distal femur periprosthetic fractures (91.7 vs. 93.6%). In other words, there are clear benefits of open reduction, yet the best implant type remains controversial. Therefore, a deep understanding of the characteristics and outcomes of periprosthetic knee fractures is necessary to determine the correct treatment.[17]

Although most distal femur periprosthetic fractures are closed injuries, open fractures are becoming more common, especially with higher energy trauma and younger patients receiving total knee arthroplasty. To our knowledge, there is no study specifically evaluating the outcomes of open distal periprosthetic femur fractures. Open distal periprosthetic femur fractures can be particularly devastating because of the complexity of the reconstruction and the high risk of complications. Multiple factors specific to open injuries can potentially contribute to poorer surgical outcomes, including bone loss and soft-tissue stripping. This adds further complexity to an already challenging[4,5] problem of treating a periprosthetic distal femur fracture.

With the above consideration in mind, we aimed to assess the outcome after operative fixation of open periprosthetic distal femur fractures in this study. One of our primary goals was to gain a greater understanding of the natural history of this type of injury. We expected open periprosthetic distal femur fractures to have higher complication rates compared with what is described in the literature currently for closed periprosthetic distal femur fractures.

2. Materials and Methods

Upon institutional review board approval, a multicenter retrospective study was conducted at 7 (6 Level I and 1 Level II) trauma centers. Patients included had medical record data available from January 1, 2009, and December 31, 2021, were aged 45 years or older at the time of injury, underwent surgical treatment of open distal femur fracture, and had undergone previous total knee arthroplasty ipsilateral to the side of the fracture. Patients excluded were those younger than 45 years at the time of injury; those with a history of infection or nonunion/malunion; those whose injury details, treatment, and outcomes were not clear or insufficient in the medical chart; those with less than 3 months of follow-up; and those whose periprosthetic fracture was initially treated with distal femoral replacement or revision arthroplasty. We specifically made the decision to focus on patients treated with ORIF and excluded those treated with an arthroplasty procedure to keep the cohort as homogenous as possible.

Each institution's electronic medical record system was searched for cases that included Current Procedural Terminology (CPT) codes for both a) open treatment of distal femur fractures and b) debridement (which would indicate that the fracture was open). See Figure 1 for the detailed list of CPT codes.

Once these cases were identified, the radiographs were manually reviewed for the presence of an arthroplasty component at the knee to find our exact population of interest. The operative reports were also reviewed to ensure that the debridement codes corresponded to the periprosthetic distal femur fracture of interest and were not due to another concomitant injury being treated simultaneously. Thirty-four patients were identified at this stage. After excluding those who did not have sufficient (greater than 3 months) follow-up, 21 patients were included in the study as the final cohort.

These patients' charts were then reviewed in detail. The demographic variables recorded were age at the time of injury, sex, race and ethnicity, comorbidities (heart disease, lung disease, liver disease, peripheral vascular disease, diabetes, renal disease, autoimmune disease, osteoporosis), smoking history, and pre-injury ambulatory status. Injury-related data, such as the mechanism and Gustilo-Anderson open fracture classification type, were also recorded. Variables related to the surgery and outcome were also collected, including the type of fixation, stability and type (primary vs. revision) of total knee implant at the time of injury, complications (thromboembolic event, infection, implant failure, nonunion, malunion, unexpected return to the operating room), need for further surgical procedures, range of motion (ROM) at final follow-up, return to baseline activity at final follow-up, and time to union based on follow-up radiographs.

3. Results

Twenty-one patients were included in the study (9 male, 12 female), all having greater than 3 months of follow-up. The mean age at the time of fracture was 72.3 years (56–85 years). One patient identified as American Indian/Alaskan Native, and 1 patient as African American/Black. The rest (19) identified as White. Eight patients (38.1%) sustained the injury by a high-energy mechanism (vehicle injuries or fall from height) as opposed to low-energy ground-level fall. Gustilo-Anderson fracture classification ranged per the following: Type I (9), Type II (6), Type IIIA (5), and Type IIIB (1). Nineteen patients had primary TKA in place at the time of fracture, and 2 had undergone revision TKA previously. All of these implants were noted to be stable at the time of fixation. The mean duration of the most recent total knee arthroplasty to fracture was 8.3 years (0.5–19.5 years), although 6 patients did not have these data available. The mean duration of postoperative follow-up from the initial procedure was 23.8 months (4.2–105.5 months). See Table 1 for a detailed list of each patient and their demographic information. In terms of comorbidities, as seen in Figure 2, the most common comorbidity present in the cohort was heart disease (9 patients), followed by diabetes (6 patients).

Table 2 summarizes treatment-related data for our cohort. All 21 patients received initial antibiotics and emergency department care according to each institution's protocol. Six patients were initially placed in an external fixator and received damage control orthopaedic intervention, or "musculoskeletal temporary surgery (MuST)," while 15 patients received early definitive fixation.[18] No patients were left in the external fixator as their definitive fixation method. Within 0–5 days, all 6 of these patients went onto receive their definitive fixation. All patients underwent irrigation and debridement at the time of initial surgery, whether that was the external fixator placement or the definitive fixation. Definitive fixation methods were either with retrograde IMN fixation (6 patients, 28.6%) or locked plating (15 patients, 71.4%). Notably, there were no patients who were fixed with combination constructs that met our inclusion criteria.

More than half of all patients (11 patients, 52.4%) had at least 1 complication during their clinical course requiring unplanned return to the operating room. Eight patients (38.1%) had a nonunion, 4 of which were septic nonunion and 4 were aseptic. Five of these patients went onto heal by final follow-up. Two patients (9.5%) had deep infections not involving a nonunion.

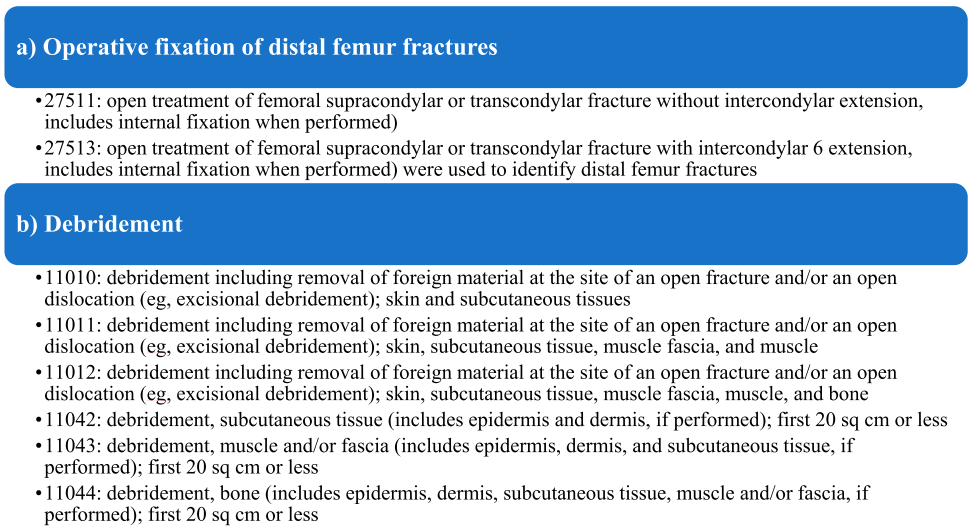

Figure 1. List of CPT codes used to search for our population of interest (open periprosthetic distal femur fracture).

Two patients (9.5%) had implant failure. One patient (4.8%) had a malunion. No patients experienced a thromboembolic event.

In total, 4 patients were placed on lifelong suppressive antibiotics. The small numbers in this study precluded statistical analysis of complication rates by Gustilo-Anderson classification type. However, we did observe higher complication rates with higher grades of open injury (complication rates based on Gustilo-Anderson type: Type 1 = 1/9, Type 2 = 4/6, Type 3A = 3/5, Type 3B = 1/1). The mean knee extension at final follow-up was 2.53 degrees (0–10 degrees) and mean knee flexion was 96 degrees (60–135 degrees). The mean delta ROM (maximum ROM − minimum ROM) was 87.6 degrees. Of 13 patients with known preoperative and postoperative activity levels, 4 were noted to have return to baseline function (30.8%) at an average time of 10.2 months. The mean time to bony union for all patients with healed status on radiographs was 20.4 ± 14.1 months.

4. Discussion

To date, this is the first study to report specifically on the characteristics of open periprosthetic distal femur fractures. The most important finding to report from this multicenter case series is the higher rate of complications after open periprosthetic distal femur fractures compared with that of closed periprosthetic distal femur fractures previously reported in the literature.

Campbell et al[19] and Miettinen et al[20] showed that the total complication rates in their cohorts of patients with periprosthetic distal femur fractures were 24% and 9.3% (at 10 years), respectively. Specifically, the nonunion rate is reported to be

Table 1

Demographic data for all patients.

Case	Sex	Age (y)	Race	MOI	GA Class	TKA to injury (y)	Comorbidities	Smoking status
1	F	60	White	MVC	3B	8.0	DM	Never
2	F	58	American Indian/Alaskan Native	MVC	2	0.5	Heart, DM	Current
3	F	68	White	GLF	1	19.5	Lung, osteoporosis	Never
4	F	81	White	GLF	1	17.0	Lung	Current
5	F	78	White	GLF	2	8.8	Inflammation/autoimmune	Never
6	M	56	White	MVC	2	12.6	None	Former
7	F	69	White	GLF	1	14.2	None	Unknown
8	F	72	White	GLF	2	8.0	Heart, DM	Unknown
9	F	61	White	GLF	1	Unknown	DM	Unknown
10	F	72	White	MVC	3A	Unknown	None	Unknown
11	M	85	White	GLF	1	11.1	Heart, DM, renal	Unknown
12	M	85	White	GLF	1	7.5	Heart, renal	Unknown
13	F	84	White	GLF	3A	1.8	Heart	Unknown
14	F	83	White	GLF	3A	8.8	Heart, lung, PVD, DM, renal	Unknown
15	M	67	White	FFH	1	12.9	Heart	Unknown
16	F	74	White	ATV/MC	3A	5.4	Heart	Unknown
17	M	73	White	GLF	2	5.3	Heart, renal	Unknown
18	M	82	White	GLF	1	Unknown	Heart	Never
19	M	57	White	MVC	3A	Unknown	Lung	Former
20	M	76	White	GLF	2	Unknown	Heart	Former
21	M	70	African American/Black	ATV/MC	1	Unknown	Heart, DM, renal, inflammation/autoimmune	Never

ATV/MC, all-terrain vehicle/motorcycle; F, female; FFH, fall from height; GA Class, Gustilo-Anderson classification; GLF, ground-level fall; M, male; MOI, mechanism of injury; MVC, motor vehicle collision; TKA, total knee arthroplasty.

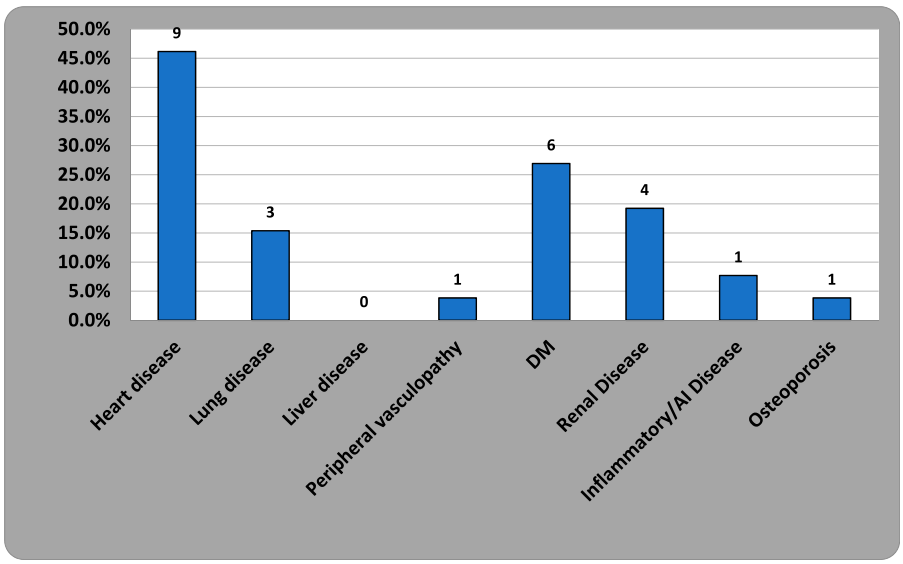

Figure 2. Counts and percentage of patients with comorbidities at the time of injury.

18% in the former study, and the reoperation rate is reported as 8.3% at 1 year and 13.8% at 10 years in the latter study. In both studies, there is no specific mention of what percentage of their cohort included open fractures. However, it is reasonable to assume that the majority were closed, owing to the rarity of open periprosthetic fractures, with the incidence of open fractures estimated to be less than 10% of all distal femur fractures.[9,21] Moreover, deep infection rates after ORIF of distal femur periprosthetic fractures in the literature range from 0% to 9% according to the review article by Wallace.[22]

In our cohort of exclusively open periprosthetic distal femur fractures, we found that the total complication rate was 52.4% (11 out of 21 patients). Specifically, the most common complication that patients experienced was nonunion followed by deep infection without a nonunion. Again, the incidence of both of these complications is higher in our cohort compared with the previous studies reporting on closed fractures. Given the high rate of infection found in this series, distal femoral replacement as the first-line choice of fixation after an open periprosthetic distal femur fracture should be chosen with caution, bcause consequences of an infected distal femoral replacement can be devastating.

Conclusion regarding how comorbidities and smoking status affected the complication rates in our cohort was difficult to make because of the limitations of our data. Of the 11 patients who had a complication, smoking status was

Table 2

Treatment data for all patients.

Case	Fixation method	Major complications	Revision surgery	Lifelong Abx?	Delta ROM final f/u	Return to baseline?
1	Retro IMN*	Deep infection	rTKA	Y	125	Y
2	Locked plate	Nonunion, deep infection	rORIF, allograft, rTKA	N	100	N
3	Locked plate	None	None	N	105	Y
4	Locked plate*	Implant failure, deep infection	rORIF	Y	87	N
5	Locked plate	None	None	N	100	N
6	Locked plate	None	None	N	100	N
7	Locked plate	Nonunion, deep infection	rORIF	Y	65	Y
8	Retro IMN	Nonunion	rORIF, allograft	N	Unknown	Unknown
9	Locked plate	None	None	N	Unknown	Unknown
10	Retro IMN*	None	None	N	Unknown	Unknown
11	Locked plate	None	None	N	Unknown	Unknown
12	Locked plate*	Nonunion	rORIF	N	85	Unknown
13	Locked plate	Malunion	rORIF	N	Unknown	Unknown
14	Locked plate	None	None	N	75	N
15	Locked plate	None	None	N	110	N
16	Locked plate	Nonunion, deep infection	rORIF	Y	50	N
17	Locked plate	Nonunion	rORIF	N	100	N
18	Retro IMN	None	None	N	100	Unknown
19	Retro IMN	Nonunion, deep infection, implant failure	rTKA	N	105	Unknown
20	Retro IMN*	Nonunion	rORIF	N	100	Y
21	Locked plate*	None	None	N	70	N

* Those who were initially placed in external fixator before definitive fixation.

Abx, antibiotics; Delta ROM = max flexion − max extension; f/u, follow-up; N, no; Retro IMN, retrograde intramedullary nail; ROM, range of motion; rORIF, revision open reduction and internal fixation; rTKA, revision total knee arthroplasty; Y, yes.

known in 5 patients, and 4 of them were either current or former smokers. Most (18 out of 21, 85.8%) of our patients had at least 1 comorbidity, which reflects the age and frailty of the population that sustains open periprosthetic distal femur fractures. One may reasonably expect complication rates to be higher in patients with multiple comorbidities or tobacco use. Although we did not have the numbers to perform a meaningful statistical analysis, further studies to investigate the association between demographic data and complication rates may be useful.

It is also notable that only a small percentage (4 out of 13, 30.8%) of the patients in our cohort returned to their functional baseline. This observation is limited by the fact that the return to baseline function status was known for a relatively small subset of our patients as well as the variety in the length of follow-up period. Future studies to compare the rate of return to baseline function for open versus closed periprosthetic distal femur fractures would be interesting. Still, because of the high complication rate and higher energy mechanism of injury, it is reasonable to suspect that return to baseline would be a challenge in this patient population, and thus, we report this as an addition to our primary outcome.

This study is limited by its retrospective nature with relatively small numbers. This is because at this present moment, open periprosthetic distal femur fractures are still relatively rare. However, the increasing life expectancy, leading to a rising annual numbers of knee replacements, will drive an increased incidence of distal periprosthetic femur fractures. By proxy, we will also see an increase in the occurrence of the open subtypes. Thus, it is crucial that we understand the outcomes of these injuries to treat and counsel these patients appropriately. In our study, we concluded that open periprosthetic fractures tend to have much poorer outcome compared with its closed counterpart and that revision surgery to treat an infection or nonunion may be necessary in the future. Given the high risk of these complications identified in this series, future research is warranted to investigate potential adjunctive techniques for managing these injuries such as local antibiotic application, staged bone grafting, or the use of dual-implant fixation (dual plating or nail-plate combinations). We also believe in the importance of larger scale studies to stratify risk factors with current comorbidity indices[23] and perhaps assess outcome according to fixation type (plating vs. intramedullary nail) for these open subtypes, which we were not able to do because of the small sample size.

This multicenter case series demonstrated high rates of complications and reoperations in patients undergoing surgery for open periprosthetic distal femur fractures, compared with the rate that is previously reported for periprosthetic distal femur fractures. This is likely to lead to a long and costly recovery course for the patients and surgeons. Therefore, these patients deserve appropriate attention in initial treatment and counseling, as well as follow-up management. More studies are needed to determine patient and surgical factors that predispose these patients to a higher risk and can potentially be mitigated.

References

1. Nauth A, Ristevski B, Bégué T, et al. Periprosthetic distal femur fractures: current concepts. *J Orthop Trauma*. 2011;25(suppl 2):S82–S85.
2. Ruder JA, Hart GP, Kneisl JS, et al. Predictors of functional recovery following periprosthetic distal femur fractures. *J Arthroplasty*. 2017;32: 1571–1575.
3. Streubel PN, Ricci WM, Wong A, et al. Mortality after distal femur fractures in elderly patients. *Clin Orthop Relat Res*. 2011;469: 1188–1196.
4. Russell GV, Kregor PJ, Jarrett CA, et al. Complicated femoral shaft fractures. *Orthop Clin North Am*. 2002;33:127–142.
5. Hoffmann MF, Jones CB, Sietsema DL, et al. Outcome of periprosthetic distal femoral fractures following knee arthroplasty. *Injury*. 2012;43: 1084–1089.
6. Capone A, Congia S, Civinini R, et al. Periprosthetic fractures: epidemiology and current treatment. *Clin Cases Miner Bone Metab*. 2017;14:189–196.
7. Benkovich V, Klassov Y, Mazilis B, et al. Periprosthetic fractures of the knee: a comprehensive review. *Eur J Orthop Surg Traumatol Orthop Traumatol*. 2020;30:387–399.
8. Rorabeck CH, Taylor JW. Periprosthetic fractures of the femur complicating total knee arthroplasty. *Orthop Clin North Am*. 1999;30: 265–277.
9. Court-Brown CM, Caesar B. Epidemiology of adult fractures: a review. *Injury*. 2006;37:691–697.
10. Della Rocca GJ, Leung KS, Pape HC. Periprosthetic fractures: epidemiology and future projections. *J Orthop Trauma*. 2011;25(suppl 2):S66–S70.
11. Shah A, Cieremans D, Slover J, et al. Trends in complications and outcomes in patients aged 65 years and younger undergoing total knee arthroplasty: data from the American joint replacement registry. *J Am Acad Orthop Surg Glob Res Rev*. 2022;6:e22.00116.
12. Su ET, DeWal H, Di Cesare PE. Periprosthetic femoral fractures above total knee replacements. *J Am Acad Orthop Surg*. 2004;12:12–20.
13. Darrith B, Bohl DD, Karadsheh MS, et al. Periprosthetic fractures of the distal femur: is open reduction and internal fixation or distal femoral replacement superior? *J Arthroplasty*. 2020;35:1402–1406.
14. McGraw P, Kumar A. Periprosthetic fractures of the femur after total knee arthroplasty. *J Orthop Traumatol*. 2010;11:135–141.
15. Rinehart D, Youngman T, Ahn J, et al. Review of patient-reported outcomes in periprosthetic distal femur fractures after total knee arthroplasty: a plate or intramedullary nail? *Arthroplasty*. 2021;3:24.
16. Dunbar RP, Egol KA, Jones CB, et al. Locked lateral plating versus retrograde nailing for distal femur fractures: a multicenter randomized trial. *J Orthop Trauma*. 2023;37:70–76.
17. Cacciola G, Mancino F, De Meo F, et al. Current reconstruction options in periprosthetic fractures around the knee. *Geriatr Orthop Surg Rehabil*. 2021;12:21514593211023996.
18. Pfeifer R, Kalbas Y, Coimbra R, et al. Indications and interventions of damage control orthopedic surgeries: an expert opinion survey. *Eur J Trauma Emerg Surg*. 2021;47:2081–2092.
19. Campbell ST, Lim PK, Kantor AH, et al. Complication rates after lateral plate fixation of periprosthetic distal femur fractures: a multicenter study. *Injury*. 2020;51:1858–1862.
20. Miettinen S, Sund R, Törmä S, et al. How often do complications and mortality occur after operatively treated periprosthetic proximal and distal femoral fractures? A register-based study. *Clin Orthop Relat Res*. 2023;481:1940–1949.
21. Kumar MD, Singh R, Khiyani R, et al. Evaluation of results of open distal femur fractures with primary fixation and antibiotic impregnated collagen. *Chin J Traumatol*. 2019;22:328–332.
22. Wallace SS, Bechtold D, Sassoon A. Periprosthetic fractures of the distal femur after total knee arthroplasty: plate versus nail fixation. *Orthop Traumatol Surg Res*. 2017;103:257–262.
23. Sinclair STT, Emara AK, Orr MN, et al. Comorbidity indices in orthopaedic surgery: a narrative review focused on hip and knee arthroplasty. *EFORT Open Rev*. 2021;6:629–640.