

# Distal femur periprosthetic knee fractures in elderly patients: clinical and radiographic outcome after internal fixation

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**Abstract.** *Background and aim of the work:* The incidence of periprosthetic knee fractures is steadily increasing, especially in the geriatric population. Surgical treatment in these patients must consider the poor bone quality and the risks of general complications related to age and comorbidities. The aim of the present study is to analyze the clinical and radiographic outcome of internal fixation for periprosthetic knee fractures of the distal femur in elderly patients (>75aa). *Methods:* All patients treated at the Orthopedic and Traumatology Unit of Cattinara Hospital-ASUGI (Trieste, Italy) between September 2014 and September 2019 for distal femur periprosthetic fracture after total knee replacement were included in the study. Mortality, complications, radiographic healing and functional outcomes were retrospectively evaluated. Data collection was conducted by clinical database searching and telephone interview. Results were compared with the literature. *Results:* The study population included 19 patients, F:M 16:3, mean age 84 years. Plate fixation was used in the majority of cases (90%). One-year mortality was 21.05%. Radiographic healing of the fracture occurred in 92% of cases. Nonetheless, 61% of patients saw a worsening in their functional outcome. *Conclusion:* Internal fixation is a valuable and safe option for distal femur periprosthetic fracture treatment in the elderly. The significant impact of periprosthetic knee fractures on the medium- to long-term survival and quality of life of the elderly patient is confirmed. ([www.actabiomedica.it](http://www.actabiomedica.it))

**Key words:** periprosthetic knee fractures, distal femur, elderly, internal fixation, osteosynthesis, functional outcome

## Introduction

Total knee arthroplasty (TKA) procedures have been steadily increasing in recent years (1-4). Likewise, periprosthetic knee fractures are growing in number. The distal femur is the most frequent fracture site with an incidence ranging from 0.3% to 2.5% of cases after primary TKA. The incidence of tibial periprosthetic fracture is reported to be between 0.4 and 1.7%, while patellar fractures occur in 0.2–21% of cases (5,6). Periprosthetic fractures are challenging in terms of treatment and patient recovery, especially in elderly

patients. In these patients, periprosthetic fractures can have a significant impact on the quality of life, in addition to the high socio-economic cost associated with functional loss in the activities of daily living (ADL). Although conservative treatment may be indicated in some cases, the majority will require surgery. The main difficulties in surgical management arise from the advanced age, poor bone quality and multiple comorbidities frequently encountered in these patients. Given the expected increase in the incidence of periprosthetic knee fractures (7), it is becoming increasingly important to adequately analyze the outcome obtained with cur-

rent treatment options. Aim of the present study is to retrospectively evaluate the clinical and radiographic results of internal fixation for distal femur periprosthetic fractures in elderly patients (>75 yrs old).

## Methods

All patients treated between September 2014 and September 2019 at the Orthopedics and Traumatology Unit of Cattinara Hospital-ASUGI of Trieste (Italy) for periprosthetic knee fracture were initially considered for the present study. The analyzed data were collected using digitally archived clinical information. Twenty-four (n = 24) patients were identified, to whom additional inclusion and exclusion criteria were applied to define a useful cohort for the study. Inclusion criteria were age  $\geq 75$  years at the time of surgery and periprosthetic fracture of distal femur after primary TKA. Exclusion criteria were: age less than 75 years at the time of surgery, patients with another lower extremity fracture in the 6 months before the periprosthetic fracture, intraoperative periprosthetic fractures, fractures after partial knee replacement, proximal tibia/patella periprosthetic fractures, and distal femur periprosthetic fractures after revision knee arthroplasty.

The data collected from medical records were age, sex, comorbidities, mechanism of injury, type of fracture according to the Lewis-Rorabeck classification (8), time elapsed between arthroplasty and fracture, type of fixation (nail, plate, cerclages), complications incurred, and any reinterventions. Subsequently, mortality was recorded by noting the time interval between surgery and death, calculating the mortality rate of the study population at 30 days, 3 months, 6 months, 1 year and cumulative. The latest available post-operative radiograph, with a minimum follow-up was used to assess fracture healing, considered as the presence of a valid bone callus at 3 to 4 cortices. Where possible, data regarding functional status before and after trauma were obtained from medical records. A telephonic survey was conducted in all patients who were alive at the time of data collection. The telephone interview occurred when possible with the patient himself or herself, or with a family member or health

care personnel if the patient was unable to speak on the telephone or hold a conversation. The purpose of the telephone survey was to complete data referring to pre- and post-fracture functional status that were not present in the medical records and to collect pain data at follow-up. Patients who were deceased at the time of the telephone survey were not considered in the analysis of functional outcome, which was assessed in absolute terms and in relation to pre-trauma function as follows: a) moves with a wheelchair, b) walks with a walker or 2 crutches, c) walks with a cane or crutch, d) walks without aids. In addition, the presence or absence of pain (whether at rest or when exerting themselves, and if they are taking major painkillers for other diseases) was assessed.

### *Statistical analysis*

Statistical analysis was performed using the IBM SPSS Statistics software. A descriptive analysis of the variables was conducted, calculating the frequency distribution for the qualitative variables. For the quantitative variables the arithmetic mean and the standard error of the mean were calculated. Afterwards, the variables were individually considered to check whether the data distribution could reveal any correlation worthy of further investigation. A Student's t-test was used for the quantitative variables, while the Chi-square test was used for categorical variables.

A p-value of less than 0.05 was considered significant. Finally, the Pearson index was used to evaluate whether significant correlations existed between the following parameters: age and time elapsed between arthroplasty/fracture, age and preoperative functional status, age and postoperative functional status, time elapsed between arthroplasty/fracture and postoperative functional outcome.

## Results

Of the 24 operated patients, 5 did not meet the inclusion/exclusion criteria. Therefore, the study population counted 19 patients. We were not able to evaluate a radiographic healing in 7 cases since the latest x-ray exam was carried out prior to 6 months from sur-

gery. Two of these patients were deceased at 6 months term, while others did not show up for radiographic control for unidentified reasons. On the other hand, the functional outcome was assessed in 13 patients as 6 of them died before the study was conducted. The mean age at the time of surgery was 84 years (range 75-94). There were sixteen female (85%) and three male patients (15%) ( $p = 0.048, < 0.05$ ). Of the 19 patients, 3 (16%) had one comorbidity, 12 (63%) had two comorbidities, and 4 (21%) had at least three or more comorbidities at the time of surgery. The mechanism of injury was a low energy trauma (accidental fall) in all cases. Analyzing the radiographs collected preoperatively according to the Lewis - Rorabeck classification, we identified 3 type I fractures (15.7%) and 16 type II fractures (84.3%). None of the patients had a type III fracture. The prevalence of type II appears to be significant according to the binomial distribution ( $p = 0.048, < 0.05$ ). The mean time between the arthro-

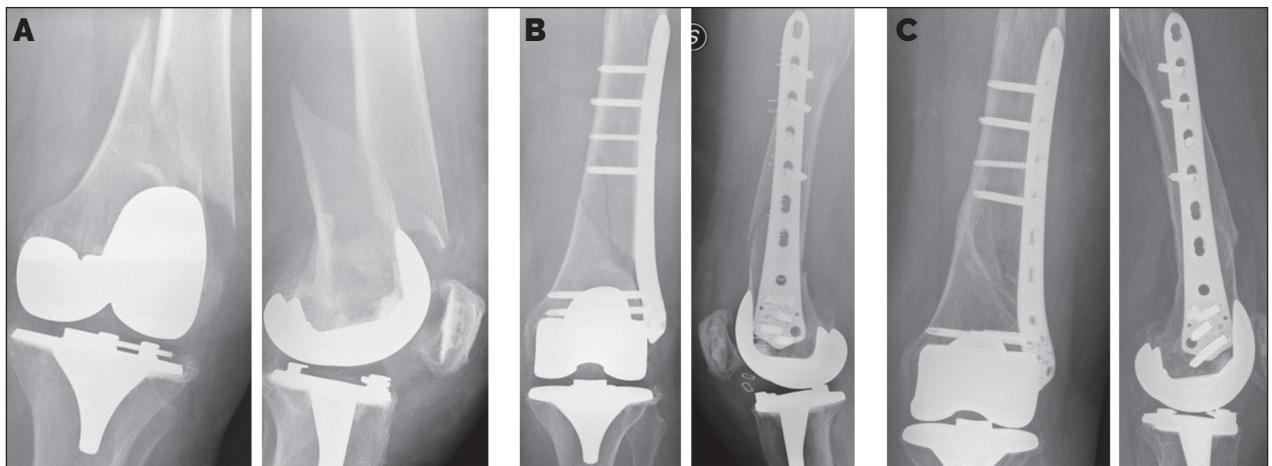
plasty procedure and the occurrence of the fracture was  $126.5 \pm 10$  months (range 10-216 months) (Table 1).

Seventeen cases (90%) were treated with dedicated angular stable locking plate for distal femur, of which 3 (18%) were LISS DF (Synthes®) and 14 (82%) were NCB plate (Zimmer®). (Figure 1.) A metal cerclage was used in 1 case (5%) and a retrograde femoral intramedullary nail was used in another case (5%). (Figure 2.) It appeared from our study that two cases (10%) had postoperative complications. In one case, there was a diaphyseal fracture of right femur, between plate and a previously implanted short cephalomedullary nail, treated with new osteosynthesis with a longer plate. In the second case, the patient had a post-operative neuroapraxia of the common peroneal nerve resolving 2 months after surgery. (Table 2.)

Mortality at 30 days was 0%, at 3 months 5.26% (1 case), at 6 months 10.53% (2 cases), and at 1 year 21.05% (4 cases). Of the 19 patients included in the

**Table 1.** The baseline characteristics, demographic and clinical data of the study population

The baseline characteristics, demographic and clinical data	
Age (mean)	84 years (75-94 years)
Sex	16 Female : 3 Male
Operated side	14 Right : 5 Left
Rorabeck classification	3 type I fractures (15.7%) and 16 type II fractures (84.3%)
Comorbidities	one comorbidity (16%), two comorbidities (63%), three or more comorbidities (21%)
Mean time between arthroplasty and fracture	$126.5 \pm 10$ months (range 10-216 months)



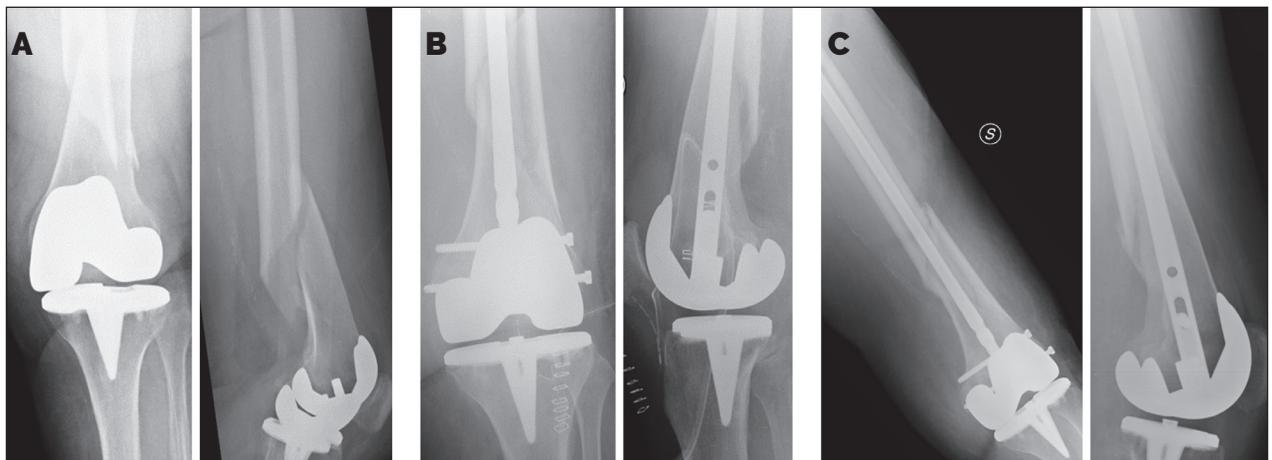
**Figure 1.** Internal fixation with plate: pre-operative (A); post-operative control (B); follow-up at 1 year with fracture completely healed (C)

study, 6 patients were deceased at final follow-up, resulting in a 31.5% cumulative mortality at mean 12.39 months (range 1.9 – 38.57). The interval between surgery and death averaged 350 days (range 57-1157) (Table 2).

In 7 cases the latest radiographic exam available was performed within 6 months from surgery. Thus, fracture healing was evaluated in 12 patients, of which

11 female and 1 male, mean age at trauma 82.33 yrs (range 75 - 90). Eleven (92%) fractures were radiographically healed at a mean 8.18 months follow-up (range 6-12). The remaining case showed an asymptomatic fibrous union at 12 months, which did not require surgery (Table 2).

Combining medical records data and the results of the telephonic interview when available, informa-



**Figure 2.** Internal fixation with plate: pre-operative (A); post-operative control (B); follow-up at 1 year with fracture completely healed (C)

**Table 2.** Treatment and outcome results

Variables		
<b>Treatment</b> (n=19)	Plate	90% (n=17)
	Metal cerclage	5% (n=1)
	Retrograd nail	5% (n=1)
<b>Mortality</b> (n=19)	30 days	0%
	3 months	5.26% (n=1)
	6 months	10.53% (n=2)
	1 year	21.05% (n=4)
<b>Radiographic Healing</b> (n=12)	Union	92% (n=11) at mean 8.18 months (range 6-12)
	Non union	8% (n=1) asymptomatic fibrous union at 12 months
<b>Pre-operative functional status</b> (n=13)	No walking aids	38.5% (n=5)
	Cane/paddle	61.5% (n=8)
	No walking aids	7.7% (n=1)
<b>Post-operative functional status</b> (n=13)	Cane/crutch	61.5% (n=8)
	Two crutches	15.4% (n=2)
	Wheelchair (not able to walk)	15.4% (n=2)
<b>Pain at follow -up</b> (n=13)	No pain	76.9% (n=10)
	Pain with physical exertion	15.4% (n=2)
	Not assessable due to major painkillers	7,7 (n=1)

tion about pre-operative and post-operative functional status was recorded in 13 patients, of which 10 female and 3 male, mean age at trauma 83.08 yrs (range 75 - 91). Before surgery, five patients (38.5%) did not use walking aids while eight patients (61.5%) used a cane/paddle to walk. At follow-up, one patient (7.7%) did not use walking aids, eight patients (61.5%) used a cane/crutch, two patients (15.4%) helped themselves with two crutches/walkers and two patients (15.4%) were no longer able to walk and were moving around in wheelchairs. On statistical analysis, crutch use was the most likely postoperative outcome ( $p = 0.046$ ). Compared with preoperative functional status, at follow-up 8 patients (61%) saw a worsening in their functional outcome and 5 patients (39%) recovered their preoperative activity level. At follow-up, 76.9% of patients had no pain, 15.4% had pain with physical exertion, and in one case (7.7%) pain could not be assessed because of concomitant major analgesic therapies taken for other diseases (Table 2).

A positive correlation between age at the time of surgery and time elapsed between arthroplasty and periprosthetic fracture ( $p = 0.0112$ ) was found using Pearson's index. In addition, there was a significant increase in the time elapsed between arthroplasty and periprosthetic fracture when there was a reduced preoperative functional status (use of aids) ( $p = 0.0112$ ).

## Discussion

In recent years, several studies have been conducted on periprosthetic knee fractures analyzing the clinical outcomes with current treatment options (5,7,10,13-19). Despite this, the optimal approach remains controversial, especially regarding the geriatric population with low functional demand.

Periprosthetic knee fractures may occur at different ages, with a wide mean age range (65-81 years) reported in the literature (3,20-22). Singh et al. observed that age 60 years or younger was associated with higher risk of postoperative periprosthetic fractures following primary TKA (23). According to the authors, a more active lifestyle and the higher functional demand in younger patients may be associated to a higher risk for trauma and consequent fracture. Conversely, Meek

et al. reported that age over 70 years was associated with an increased risk of periprosthetic fractures (24). Accordingly, the Scottish National Database reported patients older than 70 years to be 1.6 times more likely to have a fracture than younger patients (25). The present study, specifically directed to evaluation of elderly patients over 75 years, exceeds the previously reported mean ages for periprosthetic knee fractures by reaching 84 years. The prevalence of female sex in the present study (85%) is comparable to other literature reports (11,26,27). According to the Scottish National Database, it has been shown that women are 2.3 times more likely to suffer a periprosthetic knee fracture than men (25). This finding presumably reflects the higher prevalence of osteoporosis in female patients (24). Based on the authors experience and literature data periprosthetic knee fractures in the elderly should be considered as fragility fractures.

The time interval from TKA to periprosthetic fracture is widely variable, depending on patient characteristics and fracture location. For fractures of the distal femur, Gondalia et al. report a mean time interval of 25.5 months (28). On the other hand, Hoffmann et al. report for the same fracture location a much longer time interval (70 months) (12). An even longer time (126 months) results in our study, which can be attributed to the advanced mean age of the selected patients and the relative low mean activity level.

The proper indication for treatment of these injuries vary from case to case. Factors influencing surgical decision include the patient's overall health and functional demand, fracture location and morphology, bone quality, type of knee prosthetic implant, and possible loosening of prosthetic components. The present study considers only patients treated with internal fixation, which represents the treatment of choice in almost all cases in the authors experience. Nonetheless, internal fixation is the mostly used treatment modality in the literature, with locking plates and retrograde nails reported to perform better than other fixation methods (5). Bony union reached 92% of cases in the present study, which is in line with other similar studies (10, 34).

In addition to site and type of fracture, the patient's general condition is critical for the choice of treatment (29-31,33-35). Mortazavi et al. examined

20 patients with periprosthetic fractures of the distal femur after TKA. Ninety percent of these patients had significant comorbidities at the time of surgery. This study showed that the greater the number of comorbidities the greater the complications that affected the postoperative functional recovery of these patients (36). Bezwada et al. observed that out of 30 patients enrolled in a study comparing intramedullary nailing and angular stability plates, 60% had comorbidities. The presence of comorbidities negatively affected postoperative functional recovery (37). In our study, all patients (100%) had comorbidities, which is higher than described in the literature but is compatible with the higher mean age of our patients. It cannot be inferred from our results that the presence of comorbidities affected the postoperative functional recovery of our patients.

Periprosthetic fractures and subsequent surgery represent a significant challenge for frail patients with high complication and mortality rates (9,29-32). Comparison with the literature in terms of complications is difficult because of the high heterogeneity between different studies. Ebraheim et al, with a study of 27 patients with distal periprosthetic fractures of the femur after TKA operated with a plate, observed a high rate (37%) of postoperative complications, including non-union, synthesis failure, and consolidation delay (22). Consistently, Verma et al. in a recent study also reported a high rate (23.50%) of postoperative complications (non-union, implant failure, or fixation failure) (21). In our study, 10% had postoperative complications, a figure that correlates positively with the literature and may be consequent to the advanced mean age of the subjects examined. In fact, the lower functional demands of geriatric patients could translate into less stress on the implant and fracture with a relative lower incidence of mechanical problems. Nonetheless, due to the high mean age and relative post-operative mortality, the data could be distorted by patients lost at follow-up.

The literature demonstrates significant postoperative mortality for periprosthetic fractures. Lotzien et al. performed a retrospective analysis of 45 patients to highlight outcomes in patients treated with NCB plates for periprosthetic knee fractures. Their results showed an overall mortality rate of 26.7% (32).

Ehlinger et al. also reported high mortality of 33% within 1 post-fracture year (3). In our study, 1-year mortality reached 21.05%, a figure in line with that described in the literature.

The goal of surgical treatment should be functional recovery to the pre-injury activity level while minimizing complications. Recovery is generally considered when the patient recovers full weight bearing without pain, associated with radiographic healing.

Platzer et al. in their study analyzed 37 patients with periprosthetic knee fractures, comparing post-surgical functional recovery. They had 68% of the patients returning to their preinjury activity level and successful fracture healing in 91% of cases 1 year after surgery in a population aged 78.6 years on average (10). Gavaskar et al. studied postoperative functional outcome in 31 patients with mean age  $73 \pm 5$  years treated with plate. Fracture healing was observed in 84% of cases. Forty-two percent of the patients regained pre-operative activity level (34). This finding is in line with our study, where 61.5% of patients had a worsening in postoperative activity levels. Our study showed that the more the patient's age increased, the more the time elapsed between arthroplasty and fracture increased, a correlation that could be explained by the fact that these patients had a fairly limited pre-fracture activity level. It also appears that the pre-operative use of aids increased the time elapsed between implanted prosthesis and periprosthetic fracture. However, it did not change in statistical terms the postoperative functional outcome.

Hoffmann et al. examined 55 patients with periprosthetic fractures of the distal femur, and 77% of the patients had no more pain at the last follow-up and loss of ROM did not influence pain (12). Likely, the present study showed that 76.9% of patients at the time of evaluation no longer perceived pain, regardless of postoperative functional recovery. No correlation was found between pain and postoperative functional outcome.

## Conclusions

An increase in incidence of periprosthetic knee fractures is expected in the near future, especially in

the elderly population. Despite a high union rate and a low complications rate, the present study confirms the already reported high 1 year mortality rate and the high incidence of significant function loss, with most elderly patients being unable to recover pre-operative level of independency in the ADLs. No conclusive evidence could be found regarding the factors specifically affecting the outcome and clear strategies to improve the results. Main limitations of this study relate to the small sample size and retrospective study design, in addition to substantial heterogeneity between analyzed subjects and the relevant mortality rate which lead to a significant drop-out.

**Conflict of Interest:** Each author declares that he or she has no commercial associations (e.g. consultancies, stock ownership, equity interest, patent/licensing arrangement etc.) that might pose a conflict of interest in connection with the submitted article

## References

- Rahman WA, Vial TA, Backstein DJ. Distal Femoral Arthroplasty for Management of Periprosthetic Supracondylar Fractures of the Femur. *J Arthroplasty*. 2016;31(3):676-679.
- Smith WR, Stoneback JW, Morgan SJ, Stahel PF. Is immediate weight bearing safe for periprosthetic distal femur fractures treated by locked plating? A feasibility study in 52 consecutive patients. *Patient Saf Surg*. 2016;10(1):1-5.
- Ehlinger M, Adam P, Abane L, et al. Treatment of periprosthetic femoral fractures of the knee. *Knee Surgery, Sport Traumatol Arthrosc*. 2011;19(9):1473-1478.
- Sun Y, Tang P, Zheng J, et al. Optimal Design of a Non-linear Series Elastic Actuator for the Prosthetic Knee Joint Based on the Conjugate Cylindrical Cam. *IEEE Access*. 2019;7:140846-140859.
- Herrera DA, Kregor PJ, Cole PA, Levy BA, Jönsson A, Zlowodzki M. Treatment of acute distal femur fractures above a total knee arthroplasty: Systematic review of 415 cases (1981-2006). *Acta Orthop*. 2008;79(1):22-27.
- Benkovich V, Klassov Y, Mazilis B, Bloom S. Periprosthetic fractures of the knee: a comprehensive review. *Eur J Orthop Surg Traumatol*. 2020;30(3):387-399.
- Rayan F, Konan S, Haddad FS. A review of periprosthetic fractures around total knee arthroplasties. *Curr Orthop*. 2008;22(1):52-61.
- Rorabeck CH, Angliss RD, Lewis PL. Fractures of the femur, tibia, and patella after total knee arthroplasty: decision making and principles of management. *Instr Course Lect*. 1998;47:449-458.
- Whitehouse MR, Mehendale S. Periprosthetic fractures around the knee: Current concepts and advances in management. *Curr Rev Musculoskelet Med*. 2014;7(2):136-144.
- Platzer P, Schuster R, Aldrian S, et al. Management and outcome of periprosthetic fractures after total knee arthroplasty. *J Trauma - Inj Infect Crit Care*. 2010;68(6):1464-1470.
- Su ET, DeWal H, Di Cesare PE. Periprosthetic femoral fractures above total knee replacements. *J Am Acad Orthop Surg*. 2004;12(1):12-20.
- Hoffmann MF, Jones CB, Sietsema DL, Koenig SJ, Tornetta P. Outcome of periprosthetic distal femoral fractures following knee arthroplasty. *Injury*. 2012;43(7):1084-1089.
- Head JM. Periprosthetic Distal Femur Fractures: Review of Current Treatment Options. *Reconstr Rev*. 2017;7(4).
- Parrón R, Tomé F, Pajares S, et al. Treatment of Periprosthetic Knee Fractures in the Distal Femur by means of Retrograde Intramedullary Nailing. *Rev Española Cirugía Ortopédica y Traumatol (English Ed)*. 2007;51(6):314-318.
- Rao B, Kamal T, Vafe J, Moss M. Distal femoral replacement for selective periprosthetic fractures above a total knee arthroplasty. *Eur J Trauma Emerg Surg*. 2014;40(2):191-199.
- Kim W, Song JH, Kim JJ. Periprosthetic fractures of the distal femur following total knee arthroplasty: even very distal fractures can be successfully treated using internal fixation. *Int Orthop*. 2015;39(10):1951-1957.
- Konan S, Sandiford N, Unno F, Masri BS, Garbuz DS, Duncan CP. Periprosthetic fractures associated with total knee arthroplasty an update. *Bone Jt J*. 2016;98-B(11):1489-1496.
- Nauth A, Ristevski B, Bégué T, Schemitsch EH. Periprosthetic distal femur fractures: Current concepts. *J Orthop Trauma*. 2011;25(SUPPL. 1):82-85.
- Ricci WM. Periprosthetic femur fractures. *J Orthop Trauma*. 2015;29(3):130-137.
- Gan G, Teo YH, Kwek EBK. Comparing outcomes of tumor prosthesis revision and locking plate fixation in supracondylar femoral periprosthetic fractures. *CiOS Clin Orthop Surg*. 2018;10(2):174-180.
- Verma N, Jain A, Pal C, Thomas S, Agarwal S, Garg P. Management of periprosthetic fracture following total knee arthroplasty- a retrospective study to decide when to fix or when to revise? *J Clin Orthop Trauma*. 2020;11:S246-S254.
- Ebraheim NA, Liu J, Hashmi SZ, Sochacki KR, Moral MZ, Hirschfeld AG. High Complication Rate in Locking Plate Fixation of Lower Periprosthetic Distal Femur Fractures in Patients With Total Knee Arthroplasties. *J Arthroplasty*. 2012;27(5):809-813.
- Singh JA, Jensen M, Lewallen D. Predictors of periprosthetic fracture after total knee replacement: An analysis of 21,723 cases. *Acta Orthop*. 2013;84(2):170-177.
- Meek RMD, Norwood T, Smith R, Brenkel IJ, Howie CR. The risk of peri-prosthetic fracture after primary and revision total hip and knee replacement. *J Bone Jt Surg - Ser B*. 2011;93 B(1):96-101.
- Sarmah SS, Patel S, Reading G, El-Husseiny M, Douglas S, Haddad FS. Periprosthetic fractures around total knee

- arthroplasty. *Ann R Coll Surg Engl.* 2012;94(5):302-307.
26. Anakwe RE, Aitken SA, Khan LAK. Osteoporotic periprosthetic fractures of the femur in elderly patients: Outcome after fixation with the LISS plate. *Injury.* 2008;39(10):1191-1197.
  27. Chalmers BP, Limberg AK, Athey AG, Perry KI, Pagnano MW, Abdel MP. Total knee arthroplasty after distal femoral osteotomy. *Bone Jt J.* 2019;101 B(6):660-666.
  28. Gondalia V, Choi DH, Lee SC, et al. Periprosthetic supracondylar femoral fractures following total knee arthroplasty: clinical comparison and related complications of the femur plate system and retrograde-inserted supracondylar nail. *J Orthop Traumatol.* 2014;15(3):201-207.
  29. Goldberg VM, Figgie MP. The results of treatment of supracondylar fracture above total knee arthroplasty. *J Arthroplasty.* 1990;5(3):267-276.
  30. Tandon T, Tadros BJ, Avasthi A, Hill R, Rao M. Management of periprosthetic distal femur fractures using distal femoral arthroplasty and fixation - Comparative study of outcomes and costs. *J Clin Orthop Trauma.* 2020;11(1):160-164.
  31. Melani T, Sani G, Carulli C, Innocenti M. Attualità sulle fratture periprotetiche di ginocchio Periprosthetic fractures of the knee: an update. *LO SCALPELLO-OTODI Educ.* 2018;32(1):56-59.
  32. Gracia-Ochoa M, Miranda I, Orenga S, Hurtado-Oliver V, Sendra F, Roselló-Añón A. Fracturas periprotésicas de fémur sobre prótesis de cadera y rodilla. Análisis de una serie de 34 casos y revisión de las series españolas en los últimos 20 años. *Rev Esp Cir Ortop Traumatol.* 2016;60(5):271-278.
  33. Lotzien S, Hoberg C, Hoffmann MF, Schildhauer TA. Clinical outcome and quality of life of patients with periprosthetic distal femur fractures and retained total knee arthroplasty treated with polyaxial locking plates: a single-center experience. *Eur J Orthop Surg Traumatol.* 2019;29(1):189-196.
  34. Gavaskar AS, Tummala NC, Subramanian M. The outcome and complications of the locked plating management for the periprosthetic distal femur fractures after a total knee arthroplasty. *Clin Orthop Surg.* 2013;5(2):124-128.
  35. Hou Z, Bowen TR, Irgit K, et al. Locked plating of periprosthetic femur fractures above total knee arthroplasty. *J Orthop Trauma.* 2012;26(7):427-432.
  36. Mortazavi SMJ, Kurd MF, Bender B, Post Z, Parvizi J, Purtill JJ. Distal Femoral Arthroplasty for the Treatment of Periprosthetic Fractures After Total Knee Arthroplasty. *J Arthroplasty.* 2010;25(5):775-780.
  37. Bezwada HP, Neubauer P, Baker J, Israelite CL, Johanson NA. Periprosthetic supracondylar femur fractures following total knee arthroplasty. *J Arthroplasty.* 2004;19(4):453-458.
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