

Original Research Article

Periprosthetic fractures after total knee arthroplasty: an extensive review of its patterns, risk factors, treatment options, outcomes and correlation of its severity with the bone mineral density

Ravikumar Mukartihal*, Ameya A. Katariya, Udit K. Biswal, Ragavan S. K. S.,
Manideep Reddy, Sharan S. Patil

Department of Orthopaedics, Sparsh Super Specialty Hospital, Infantry Road, Bangalore, India

Received: 21 July 2025

Revised: 19 August 2025

Accepted: 20 August 2025

*Correspondence:

Dr. Ravikumar Mukartihal,

E-mail: ravikumarmukartihal@gmail.com

Copyright: © the author(s), publisher and licensee Medip Academy. This is an open-access article distributed under the terms of the Creative Commons Attribution Non-Commercial License, which permits unrestricted non-commercial use, distribution, and reproduction in any medium, provided the original work is properly cited.

ABSTRACT

Background: Periprosthetic fracture (PPF) around knee is a rare but debilitating complication after total knee arthroplasties.

Methods: Retrospective analysis of 12,133 knee replacements done at a single centre from 2011-2024 was done to analyse incidence, risk factors, pattern, treatment and outcomes of PPF and correlation of its severity with the Bone mineral Density.

Results: The incidence of PPF was 0.42% (femur=0.34%, tibia=0.07% and patella=0.01%). 51.6% were female patients. Mean age, BMI, CCI and follow up was 63.32 (22-89 years; SD=13.51), 30.6 (20.2-43.8; SD=3.9), 2.2 (1-4; SD=0.77) and 5.1 years (1-14 years; SD=4.29). Mean BMD was -1.78 (1 to -3; SD=0.69). Primary osteoarthritis was the diagnosis in 93.91% and PFC Sigma (Depuy, Johnson and Johnson) posterior stabilised prosthesis was used in 88% of the patients. The mean grade of anterior cortex notching (Tayside classification) was 0.39 (0-3, SD=0.12). Only female gender was a significant risk factor for PPF (OR=3.1; 2.31-3.97 at 95%CI; p value=0.01). There was no significant correlation between the BMD and the grade of fracture as per Lewis and Rorabeck, Su and Felix classifications (p values=0.77, 0.80 and 0.74 respectively). 33 PPFs (64.7%) were fixed with locking plates and 5 (9.8%) were revised to hinged prosthesis. 98% fractures united at mean 17.8 weeks and Mean KSS at 1 year was 144.77±2.08. 1 year mortality rate post PPF was 2%.

Conclusions: While female gender is a significant risk factor for PPF, BMD does not correlate with its severity. Appropriate treatment option selected based on the general health of the patient, fracture pattern and implant stability results in good outcomes and less mortality.

Keywords: Bone mineral density, Distal femur fracture, Periprosthetic fracture, Revision Total knee arthroplasty, Risk factors, Total knee arthroplasty

INTRODUCTION

Total knee arthroplasty (TKA) is the gold standard treatment for advanced arthritis of the knee and is now considered to be one of the most successful orthopaedic surgeries. As the number of TKAs continue to rise, the number of complications associated with it, although very small in proportion, tend to rise along with it.¹

Periprosthetic fractures (PPF) are one of the most dreaded complications after TKA with its reported incidence being less than 5%.²⁻⁴

Old age, female gender, rheumatoid arthritis, prolonged steroid use, osteoporosis, anterior femoral notching, neurological disorders and highly constrained implants are the commonly reported risk factors for PPF.⁵ While trivial

fall is the most common mechanism of PPF, conservative management, fixation with locking plates or intramedullary nail and revision TKA are the main modalities of treatment for this condition.^{1,5} The femur remains the most common bone to fracture after TKA and its incidence ranges between 0.3-2.5%.² Rorabeck et al and Taylor et al have classified these fractures according to the fracture displacement and fixation of the prosthesis.⁶ Type I and type II are a non-displaced and displaced fracture around a well-fixed prosthesis respectively. Type III fractures is associated with component loosening/instability irrespective of the fracture pattern. Su et al, described a classification based on the height of a fracture line relative to the femoral component.⁷

Type I fractures are proximal to the femoral component; type II fracture lines originate below the proximal end of the femoral component and extend proximally and type III fractures occur distal to the upper edge of the femoral component. The prevalence of PPF of the tibia is comparatively lower and ranges between 0.4-1.7%.^{3,8} Felix et al classified them into four types based on the fracture line location.⁸ Type I fractures are located at the tibial plateau, type II fractures occur inferior to the tibial plateau near the tibial keel, type III fractures occur distal to the tibial keel and type IV fractures involve the tibial tuberosity.

The incidence of patellar fractures has been reported as 0.2%-21% in the patella-resurfaced knee and around 0.05% in the non-resurfaced knee.^{4,9} To the best of our knowledge, there has been no study so far that evaluates correlation the severity of PPF and patient demographics. Moreover, high volume comprehensive reviews of PPFs are lacking the Indian subcontinental region where National joint registry is not well developed. The present study aims to review our more than 12 thousand cases of primary TKAs for the incidence, risk factors, pattern, treatment and outcomes of the cases of PPFs. Additionally, it also aims to evaluate the correlation between the bone mineral density (BMD) and the severity of the PPF.

Aims and objectives

To calculate incidence of periprosthetic fractures, to assess risk factors associated with periprosthetic fractures, to assess correlation between bone mineral density (BMD) and the severity of periprosthetic fracture and to evaluate mode of treatment and outcomes of the periprosthetic fractures.

METHODS

The present study is a retrospective analysis of 12133 TKAs performed at Sparsh super speciality Hospitals, Bangalore, India, by two surgeons from January 2011 to December 2024. All TKAs performed in this period were included in this study. Approval was obtained from the institutional ethics board. All patients were operated in supine position, using medial parapatellar approach and

conventional instrumentation. None of the patellae were resurfaced. Patients are followed up after discharge at 2 weeks, 6 weeks, 3 months, 6 months, 1 year and yearly thereafter.

Knee ROM and quadriceps strengthening exercises were advised during rehabilitation. Patients were advised to use walking aids for first 6 weeks post operatively a walking frame for week 0-2, 2 crutches for week 2-4, walking stick or single crutch for week 4-6. All patients were encouraged to walk without support and drive after 6 weeks post operatively.

However, those having an unstable gate, at risk of fall or were less confident were advised to use a walking stick for longer duration or even forever in selected cases. The following data was collected using the out-patient and in-patient hospital records as well as telephonic contact to the patients. Assessment of Bone mineral density (BMD) using DEXA scan has been a part of our routine pre-operative workup before TKA since 2011.

Demographic parameters

Age, gender, comorbidity scoring using the charlson comorbidity index (CCI)¹, body mass index (BMI), bone mineral density (BMD) and past medical and surgical history

Primary surgery parameters of total knee arthroplasty

Date of surgery, diagnosis, details of the prosthesis and grade of notching in femur by Tayside classification periprosthetic fracture parameters-incidence of periprosthetic fracture, correlation of the demo-graphic and primary TKA parameters with the incidence, date of injury and time since index surgery in months, mechanism of injury-twisting injury/ domestic fall/ road traffic accident/ un-known, fracture classification (Rorabeck and Taylor classification and Su and associates classification for distal femur and felix classification for proximal tibia fractures were employed), correlation of the fracture classification with BMD score, management conservative/ surgical, method- intramedullary nailing, plating, arthrodesis or revision arthroplasty and complications.

Statistical analysis

Statistical analysis software used were Microsoft Excel, StatPlus and IBM SPSS version 12. Incidence of periprosthetic fractures was calculated using percentages.

All pre op demographics and primary TKA parameters were assessed for correlation with risk of fracture using 2n number of controls who did not have periprosthetic fractures using Chi-square and Fischers exact test. Regression analysis and ANOVA test was used to calculate the correlation of BMD and the classification of the periprosthetic fracture.

RESULTS

Demographic and primary surgery parameters

Total 12133 patients were included in the study. Mean age was 63.32 years (22-89 years; SD=13.51). 5872 (48.4%) were male and 6261 (51.6%) were female patients. Mean BMI, CCI and follow up was 30.6 (20.2-43.8; SD=3.9), 2.2 (1-4; SD=0.77) and 5.1 years (1-14 years; SD=4.29). Mean BMD was -1.78 (1 to -3; SD=0.69). Primary osteoarthritis was the indication of TKA in 93.91% and PFC Sigma (Depuy, Johnson and Johnson) posterior stabilized was the prosthesis used in 88% of the patients. The mean grade of anterior cortex notching (immediate post op X-ray, Tayside classification) was 0.39 (0-3, SD=0.12) with only 1 case of grade 3 notching.

Periprosthetic fracture incidence

Out of the 12133 patients included, 51 (0.42%) had periprosthetic fracture. Incidences of PPF specific to femur, tibia and patella were 0.34%, 0.07% and 0.01% respectively.

Risk factors for periprosthetic fracture

Incidence of periprosthetic fracture was 0.20% (12/5872) in males and 0.62% (39/6261) in females (OR=3.1; 2.31-3.97 at 95%CI; p value=0.01). There was no significant correlation found between the risk of periprosthetic fracture with age, BMI, CCI, BMD, primary diagnosis and grade of notching (Table 1).

Fracture pattern and correlation of fracture severity with BMD

Out of 51 cases of periprosthetic fractures, 41 (80.4%) involved distal femur, 9 (17.6%) involved proximal tibia and one (2%) patella fracture. According to the Rorabeck and Taylor classification, 25 (61%) distal femur fractures belonged to type II, 13 (31.7%) to type I and 3 (7.3%) to type III. Whereas, as per the Su classification, 20 (48.8%) were type II, 13 (31.7%) were type I and 8 (19.5%) were type III. Among the tibial fractures, 4 (44.44%) belonged to Felix type III, 4 (44.44%) to type II, 1 (11.11%) to type I and none to type IV. There was no significant correlation

between the BMD and the grade of fracture as per Lewis and Rorabeck, Su and Felix classifications (p values=0.77, 0.80 and 0.74 respectively).

Mode of treatment and outcomes

Locking plates was the most common mode of treatment and was used in 33 patients (64.71%). Other methods of fixation (number of patients) included intramedullary nailing (3), cancellous screws (3), cerclage wires (3) and tension band wiring with cerclage wires for the patella fracture (Table 5). Three patients with undisputed fractures were treated non operatively with long knee brace immobilisation and non-weight bearing mobilisation with walking frame for 6 weeks. Five patients (3 patients with Rorabeck and Taylor type III and one patient each with Felix type I and type II) had to be revised to a hinged prosthesis due to the loosening of primary prosthesis. Out of the 46 patients that had fixation, the fracture united in 45 patients at a mean duration of 17.8 weeks.

One patient with distal femur fracture (type II Rorabeck and Taylor, Type II Su) which was fixed with dual plating, ended up in non-union and was revised to distal femur tumour prosthesis. She developed 20 degrees extensor lag post operatively but maintained mobility with an extension brace and a walking stick. The five patients that had the hinged prosthesis, had good function and mobility at one year post operatively. The patient with patella fracture developed pain 18 months post-operatively at the quadriceps insertion due to an impinging wire. After confirming that the fracture is healed, k-wires and cerclage wires from the patella were removed. She had good symptomatic relief and continued to have good extensor mechanism post-operatively.

The mean range of flexion achieved in our study at the last available follow up was 98.87 $\pm$ 11.08°. 15.7% of the knees (n=8) had a residual extensor lag with the mean lag of 9.4° (range 5-20). Similarly, 11.8 % of the knees (n=6) had a residual flexion deformity with a mean lag of 6.67° (range 5-10). Functional outcomes measured by the new Knee Society Score yielded a mean score of 144.77 $\pm$ 2.08 at 1 year follow-up. Out the 3 patients treated non operatively, 1 (2%) patient died due to PE at 8 weeks post fracture.

Table 1: Risk analysis of periprosthetic fractures.

Factor	Chi square / Fischers exact test p value
Age	0.503
Gender	<0.01
BMI	0.254
BMD	0.569
CCI	0.597
Diagnosis	0.680
Side of surgery	0.501
Anterior femoral notching	0.073

Table 2: correlation of BMD and Rorabeck and Lewis classification.

	df	SS	MS	F	Significance F
Regression	1	0.050155135463644	0.050155135463644	0.0800653594771192	0.778400826069
Residual	49	30.6949429037521	0.626427406199021		
Total	50	30.7450980392157			

Table 3: correlation of BMD and Su classification.

	df	SS	MS	F	Significance F
Regression	1	0.0378649737736829	0.0378649737736829	0.060421715983213	0.806857357776038
Residual	49	30.707233065442	0.626678225825347		
Total	50	30.7450980392157			

Table 4: correlation of BMD and Felix classification.

	df	SS	MS	F	Significance F
Regression	1	0.0683169701042132	0.0683169701042132	0.109122646459054	0.742553495430416
Residual	49	30.6767810691115	0.626056756512479		
Total	50	30.7450980392157			

Table 5: Methods of management of the periprosthetic fractures.

Treatment method	No of fractures	%
Locking plate fixation	33	64.71
Intramedullary nailing	3	5.88
Intra-op fractures fixed with cancellous screws	3	5.88
Cerclage wires	4	7.84
Revision to hinged knee	5	9.8
Non operative	3	5.88
Total	51	100

DISCUSSION

The present study evaluated 12133 cases of primary TKAs and observed the incidence of PPF to be 0.42%. The incidence of femoral (0.38%) and tibial (0.07%) PPF was within the range reported in the literature.^{2,3,8} However, this study reported only 1 case of patella fracture (0.01%) which is lower than that reported for the non-resurfaced patellae (0.05%).^{4,9}

This study showed that female gender is a significant risk factor for developing this complication (OR=3.1; 2.31-3.97 at 95%CI; p value=0.01) which has been reported before by Yoo et al.^{5,10} post-menopausal women show marked fall in the levels of estrogen, the hormone that prevents bone resorption in females. Additionally, they also show reduced levels of estrone and leptin which stimulate the osteoblastic activity. These hormonal changes combined with the increased tendency to fall in women, make them more prone for fracture after TKA.¹⁰ On the other hand age, anterior femoral notching, CCI, BMI, BMD, diagnosis and laterality failed to demonstrate significant correlation with the incidence of PPF (p values=0.5, 0.07, 0.59, 0.25, 0.57, 0.68 and 0.5 respectively) (Table 1). Most studies have recognised age

as an important independent risk factor for PPF due to increased osteoporosis and risk of fall with older age.^{4,11} However, Singh et al, have demonstrated that the said risk is higher for patients aged less than 60 as compared to those between 60 to 80.¹² This is due to the increased post TKA life years in younger patients. The present study results support this claim. Similarly, the correlation of anterior femoral notching and the rate of supracondylar femur fracture is debatable.¹³⁻¹⁶ This study agrees with Puranik et al and Gujarathi et al, by demonstrating no correlation between the two.^{13,14}

Majority of the femur fracture were Rorabeck and Taylor type II (61%) or Su type II (48.8%), whereas Felix type II and III contributed for the majority of the tibial fractures (44.44% each). Since the literature reports that old age and osteoporosis are risk factors for PPF, it can be argued that the bone mineral density should negatively correlate with the severity of the PPF. However, to the best of our knowledge, no study has analysed this correlation to this date. The present study demonstrated no correlation between BMD and severity or the incidence PPF. One possible explanation to this could be the confounding due to young patients (<60 years old) undergoing TKA. Compared to the elderly, they have good BMD at the time

of primary surgery but have higher risk of PPF due to increased post TKA life years.¹² Another potential reason could be poor correlation of the overall BMD and the bone strength specific to distal femur and proximal tibia. As the BMD is an average of the density of hip, wrist and spine, it may not be accurate in representing the bone strength around the knee. Although Yoon et al, have demonstrated good correlation between central knee BMD, the sample size was small and the population belonged to different ethnicity.¹⁷ More RCTs with bigger sample size are required to evaluate this association.

Majority of the fractures (64.7%) were treated by fixation using locking plates (Table 2). Literature reports this to be the most widely accepted mode of treatment for PPF, especially around distal femur.¹⁸ Proximal tibial fractures have a higher risk of implant loosening than the distal femur fractures.¹⁹ This aligns with the present study where, out of the 5 patients that underwent revision TKA, 2 (40%) were on tibial side. We demonstrated excellent union rate of 98 % and good functional outcome which is comparable to the literature.^{1,5,19} 1 year mortality rate in this study was 2% (1 patient). This patient was a 79 years old female that had Totabeck and Talor type I fracture. She was treated non operatively due to very high cardiac risk. Presence of comorbidities, old age and non-operative treatment are associated with higher mortality after PPF.^{20,21} However, our mortality rate is significantly lower than 6.4% and 17% reported by Nasser et al and Irfan et al, respectively.^{20,21}

The strengths of this study are large sample size, no selection bias, more comprehensive analysis of various aspects of PPF in a single study and first study to analyse the correlation of BMD with the severity of the fracture. Retrospective and single center design are some of the pitfalls.

CONCLUSION

Female gender predisposes significant risk to develop periprosthetic fracture after TKA. BMD does not correlate with the incidence or the severity of the fracture. While distal femur is the commonest site, fixation with locking plates is the most widely used treatment modality for PPFs. Appropriate treatment option selected based on the general health of the patient, fracture pattern and implant stability results in good outcomes and less mortality.

ACKNOWLEDGEMENTS

We thank K. Soujanya, Wilson Group Head Clinical Research, Sparsh Hospitals Bangalore

Funding: No funding sources

Conflict of interest: None declared

Ethical approval: The study was approved by the Institutional Ethics Committee

REFERENCES

1. Benkovich V, Klassov Y, Mazilis B. Periprosthetic fractures of the knee: a comprehensive review. *Eur J Orthop Surg Traumatol.* 2020;30:387–99.
2. Kim KI, Egol KA, Hozack WJ, Parvizi J. Periprosthetic fractures after total knee arthroplasties. *J Clin Orthop Relat Res.* 2021;446:167–75.
3. Parvizi J, Jain N, Schmidt AH (2008) Periprosthetic knee fractures. *J Orthop Trauma* 22(9):663–671
4. Canton G, Ratti C, Fattori R, Hoxhaj B, Murena L. Periprosthetic knee fractures. A review of epidemiology, risk factors, diagnosis, management and outcome. *Acta Biomed.* 2017;88:118–28.
5. Yoo JD, Kim NK. Periprosthetic fractures following total knee arthroplasty. *Knee Surg Relat Res.* 2015;27(1):1-9.
6. Rorabeck CH, Taylor JW. Classification of periprosthetic fractures complicating total knee arthroplasty. *Orthop Clin North Am.* 1999;30:209–14.
7. Su ET, DeWal H, Di Cesare PE. Periprosthetic femoral fractures above total knee replacements. *J Am Acad Orthop Surg.* 2004;12:12–20.
8. Felix NA, Stuart MJ, Hanssen AD. Periprosthetic fractures of the tibia associated with total knee arthroplasty. *Clin Orthop Relat Res.* 1997;(345):113–24.
9. Goldberg VM, Figgie HE, 3rd, Inglis AE, Figgie MP, Sobel M, Kelly M, et al. Patellar fracture type and prognosis in condylar total knee arthroplasty. *Clin Orthop Relat Res.* 1988;(236):115–22.
10. Li H, Liu C, Jin G, Teng Y, Zhang W, Jin R. Risk factors for periprosthetic fractures after total knee arthroplasty: a systematic review and meta-analysis. *J Arthroplasty.* 2024;2:544
11. Pornrattanamaneewong, C., Sitthitheerarat, A., Ruangsomboon, P., et al. Risk factors of early periprosthetic femoral fracture after total knee arthroplasty. *BMC Musculoskelet Disord.* 2021;22:1009.
12. 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):170–7.
13. Puranik HG, Mukartihal R, Patil SS, Dhanasekaran SR, Menon VK. Does femoral notching during total knee arthroplasty influence periprosthetic fracture. a prospective study. *J Arthroplasty.* 2019;34(6):1244–9.
14. Gujarathi N, Putti AB, Abboud RJ, MacLean JG, Espley AJ, Kellett CF. Risk of periprosthetic fracture after anterior femoral notching. *Acta Orthop.* 2019;80(5):553-6.
15. Lesh ML, Schneider DJ, Deol G. The consequences of anterior femoral notching in total knee arthroplasty: a biomechanical study. *J Bone Joint Surg Am.* 2019;821096-101.

16. Ritter, MA, Thong, AE, Keating, EM. 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*. 2019;87:2411-4.
17. Yoon C, Chang MJ, Chang CB, Chai JW, Jeong H, Song MK, et al. Bone Mineral Density Around the Knee Joint: Correlation with central bone mineral density and associated factors. *J Clin Densitom*. 2020;23(1):82–91.
18. Caterini A, Luciano C, Rovere G, Ziranu A, Farsetti P, De Maio F. Periprosthetic distal femoral fractures after total knee replacement treated by ORIF. Mid to long-term follow-up study in 12 patients. *Orthopedic Reviews*. 2023;15:586.
19. Saurabh A, Jitesh J. Periprosthetic fractures after total knee arthroplasty. *J Orthopaed Surg*. 2014;22:24-9.
20. Nasser AAHH, Sidhu M, Prakash R, Mahmood AK, Chauhan GS. The characteristics and predictors of mortality in periprosthetic fractures around thnee. *Bone Joint J*. 2024;106(2):158-65.
21. Ahmad I, Zeb J, Ayyaz H, Mushtaq HS, Aziz M, Chaudhry F. Risk factors of mortality in patients with periprosthetic fractures: an experience of 100 cases. *Cureus*. 2025;17(2):79863.

Cite this article as: Mukartihal R, Katariya AA, Biswal UK, Ragavan SKS, Reddy M, Patil SS. Periprosthetic fractures after total knee arthroplasty: an extensive review of its patterns, risk factors, treatment options, outcomes and correlation of its severity with the bone mineral density. *Int J Res Orthop* 2025;11:1191-6.