ASIAN JOURNAL OF PHARMACEUTICAL AND CLINICAL RESEARCH

INNOVARE ACADEMIC SCIENCES
Knowledge to Innovation

Vol 16, Issue 7, 2023

Online - 2455-3891
Print - 0974-2441

Research Article

EVALUATION OF FUNCTIONAL OUTCOME OF SURGICAL TREATMENT FOR FRACTURE AROUND KNEE WITH LOCKING PLATE

VIKAS KUNTWAD[1]*, AMOL WAGH[1], SATYAJEET A HORE[2]

[1]Department of Orthopaedics, JIIU's IIMSR Medical College, Warudi, Badnapur, Maharashtra, India. [2]Department of Orthopaedics, Prakash Institute of Medical Sciences, Uran Islampur, Maharashtra, India.
***Corresponding author: Dr. Vikas Kuntwad; Email: vikaskuntwad@gmail.com**

Received: 04 June 2023, Revised and Accepted: 25 July 2023

ABSTRACT

Objectives: The aim of the study was to evaluate clinical and radiological outcome associated with surgical treatment of fracture around the knee treated by locking plates.

Methods: This was an observational follow-up study in which 40 patients who were having fractures around knee (Distal femoral or proximal tibial fractures) and treated by locking plates were included on the basis of a predefined inclusion and exclusion criteria. All patients were surgically treated by locking plates. Functional outcome was assessed by range of flexion, knee score and functional score. Complications such as wound infection, malunion, and non-union were also studied. P value < 0.05 was taken as statistically significant.

Results: There was an overall male preponderance with M: F ratio being 1:0.11. Road traffic accidents were responsible for 90% fractures. Average range of knee flexion was 88.5º in patients with distal femur fracture, and 106.5° in patients with proximal tibia fracture. Average Knee society score was 82.35 points in patients with distal femur fracture, and 88.55 points in patients with proximal tibia fracture. There were three cases with non-union, all of them united after secondary bone grafting. Superficial infection was seen in total of two patients.

Conclusion: Surgical treatment of fracture around the knee by locking plates gives excellent results in terms of range of flexion as well as functional outcome particularly in cases having extra-articular fractures.

Keywords: Proximal tibial fracture, Distal femur fracture, Knee society score, Functional outcome.

 DOI: http://dx.doi.org/10.22159/ajpcr.2023v16i7.48875. Journal homepage: https://innovareacademics.in/journals/index.php/ajpcr

INTRODUCTION

Knee joint is one of the most common joints to be involved in injuries. The common causes of injuries around knee include sports injuries, road traffic accidents (RTA), and falls from height. Optimum management of injuries around knee is crucial in maintaining good knee function. With rapid industrialization, there is an exponential increase in the incidence of RTA as well as workplace related injuries such as falls from height. All these accidents are prone to cause injuries around knee. In relatively young patients, considerable force is required to cause these injuries; however, in old age patients, even a trivial trauma or twisting force can cause these fractures [1].

Fracture lower end of femur and upper end of tibia are often difficult to treat and they are associated with many complications. These are serious injuries that frequently result in functional impairment, as they disturb knee alignment, stability, and movement [2].

Fractures of the distal femur have been reported to account for between 4% and 7% of all femoral fractures, 31% of femoral fractures involve distal femur. Distal femoral fractures mainly arise from two different injury mechanisms. They are often caused by high energy trauma mainly sustained in RTA [3]. Open injuries with considerable communication of condyles and metaphysis are frequently seen, as is low energy trauma, relating to elderly patients with severe osteoporosis frequently seen as periprosthetic fracture. In high-energy trauma, the problem of restoring the function in a destroyed knee joint persists. Complex knee ligament injuries frequently occur additionally to extensive cartilage injuries. The "fatigue failure" of the osteoporotic implant-bone construct is a problem in elderly patients [4].

Fractures of the proximal tibia particularly those that extend into the knee joint are termed as tibial plateau or tibial condylar fractures. Proximal tibia makes about 1% of all fractures and 8% of the fractures in elderly. Most injuries affect lateral tibial condyle (55–70%) and isolated medial condyle fractures occur in 10–23% whereas the involvement of bicondylar lesions is found in 10–30% of the reported series [5].

In the early 1960s, there was a great reluctance toward operative management of these fractures because of high incidence of infection, non-union, malunion, inadequate fixation, and lack of proper instruments, implant as well as antibiotics. Then, the traditional management of displaced fracture supracondylar of femur was along the principle of John Charnley. This comprised of skeletal traction, manipulation of fracture, and external immobilization in the form of casts and cast bracings. These methods however met with problems such as deformity, shortening, prolonged bed rest, knee stiffness, angulation, joint incongruity, malunion, quadriceps wasting, knee instability, and post-traumatic osteoarthritis [6].

The aim of surgical treatment of distal femur fracture and proximal tibia fracture is to restore congruent articular surfaces of the condyles, maintaining the mechanical axis and restoring ligamentous stability. Thus, eventually, it can achieve functional painless and good range of motion in the knee joint [7].

We conducted this observational study to analyze the functional outcome of patients having fracture around knee who were treated by locking plates.

METHODS

This was an observational follow-up study in which 40 patients who were having fractures around knee (Distal femoral or proximal tibial fractures) and treated by locking plates were included on the

basis of a predefined inclusion and exclusion criteria. The study was conducted in the department of orthopedics of a tertiary care medical college. Institutional ethical committee approved the study and written and informed consent was obtained from all the participants of the study. The sample size was calculated on the basis of pilot study done on the topics of fractures around knee joint. Assuming 90% power and 95% confidence interval, the sample size required was 35 patients. Thus, we included total 40 patients in our study.

A detailed history was taken with respect to nature of trauma and a through clinical examination was done to exclude possibility of polytrauma. After hemodynamic stabilization is achieved imaging studies such as X-rays were done. In selected cases, 3D CT was also done. All basic investigations including complete hemogram, blood grouping, and viral markers were carried out. Physician's opinion was sought in cases above the age of 45 years. Preparation was done till the hip. All patients were electively posted after getting pre-anesthetic evaluation.

Surgical procedure

The distal femoral fractures were treated by lateral approach which is described. The modification to standard lateral approach was done in some cases depending on the type of fracture. Proximal tibial fractures were treated by anterolateral approach.

A radiolucent operating table facilitated use of an image intensifier during the procedure. The patient was positioned supine with the ipsilateral hip elevated to allow slight internal rotation of the leg. Alternatively, the patient may be placed in the lateral position. The leg was draped free. With the patient in the supine position, a sterile bolster was placed under the knee to facilitate exposure and reduction.

A single straight lateral incision was made along the thigh. The incision was taken from as proximal as necessary and distally it extended across the midpoint of the lateral condyle anterior to the fibular collateral ligament, across the knee joint, and then anteriorly to end distal and lateral to the tibial tubercle. The fascia lata was then incised in line with the skin incision. At the knee, the iliotibial tract incised, and the incision was continued down through the joint capsule and synovium to expose the lateral femoral condyle. The vastus lateralis muscle was carefully elevated from the intermuscular septum and was retracted anteriorly and medially. Fracture reduction was done and confirmed under C-arm. Plates were inserted in sub muscular plane and proper placement of plates was confirmed with C-arm and maintained with K-wire/drill bit. Following procedure wound was closed layer by layer (Fig. 1).

The patients were asked to start static quadriceps exercises soon after surgery followed by passive range of motion with protected knee brace up to 6 weeks. After 6 weeks, partial weight bearing was started. Patients were followed up at 1 month, 3 month, 6 months, and 1 year. During each follow-up visit, X-rays were taken and functional assessment was done using knee-society score. SSPS 21.0 software was used for statistical analysis and $p<0.05$ was taken as statistically significant.

Inclusion criteria

The following criteria were included in the study:

1. Patients having fractures around knee (Distal femoral or proximal tibial fractures) and treated by locking plates.
2. Those who gave informed written consent to be part of study.
3. Age above 18 years.

Exclusion criteria

The following criteria were excluded from the study:

1. Patients who refused consent.
2. Patients with Type 3 open fracture and significant bone loss.
3. Uncontrolled diabetes, hypertension, or any other serious systemic illnesses.
4. Patients having serious comorbid conditions likely to affect the assessment of functional outcome such as patients with neoplastic diseases, stroke, or rheumatoid arthritis.
5. Pathological fractures.

RESULTS

Out of 40 studied cases, there were 34 male patients and six female patients. There was an overall male preponderance with M:F ratio being

Table 1: General details and type of fractures in studied cases

General details and type of fractures	Distal femur fracture		Proximal tibia fracture	
	No of cases	percentage	No of cases	percentage
Gender distribution				
Male	17	42.50	17	42.50
Female	3	7.50	3	7.50
Total	20	50.0	20	50.0
Mode of injury				
RTA	18	45.0	18	45.0
Fall	2	5	2	5
Total	20	50.0	20	50.0
Side of fracture				
Right	15	37.50	12	30.00
Left	05	12.50	8	20.00
Total	20	50.0	20	50.0
Age in years				
<50 years	14	35.00	16	40.00
>50 years	06	15.00	10	20.00
Total	20	50.0	20	50.0
Open versus closed fractures				
Open	06	15.00	14	35.00
Closed	02	5.00	18	45.00
Total	8	20.0	32	80.0
Injury to surgery interval (days)				
1–3	2	5.00	3	7.50
4–7	12	30.00	12	30.00
>7	6	15.00	5	12.50
Total	20	50.0	20	50.0

1:0.11. RTAs were responsible for 90% of fractures of distal femur and proximal tibia. In our study, the right side was involved more than left side, contributing to 27 (67.50%) cases. Two patients had distal femur fracture and proximal tibia fracture was seen in two cases with a history of fall on floor. All of them were more than 50 years of age. Out of 40 studied cases, predominant fractures were close fractures which were seen in 32 (80%) cases whereas in 8 (20%) patients, the fractures were open fractures. In our study, most of the patients were operated between 4 and 7 days after injury (60%) (Table 1).

Table 2: AO classification of fractures in studied cases

AO classification of fractures	Total	Percentage
Proximal tibia fracture		
A1	0	0.00
A2	3	7.50
A3	7	17.50
B1	0	0.00
B2	0	0.00
B3	1	2.50
C1	1	2.50
C2	7	17.50
C3	1	2.50
Total	20	50
Distal femur fracture		
A1	3	7.50
A2	3	7.50
A3	4	10.00
B1	0	0.00
B2	0	0.00
B3	0	0.00
C1	0	0.00
C2	4	10.00
C3	6	15.00
Total	20	50

The fractures were classified on the basis of AO classification. Among proximal tibial fractures, the most common type of fractures was A3 (17.50%) and C2 (17.50%) whereas among distal femur fractures, the most common type of fracture was C3 (15%) type of fracture (Table 2).

Patients were followed up till 1 year. During follow-up visits, X-rays were done to assess the status of union. Out of 40 fractures operated, 37 fractures were united within 20 weeks of surgery. Mean time of union was 17 weeks for distal femur fractures and 15.4 weeks for proximal tibia fractures (Table 3).

Average range of knee flexion was 88.5° in patients with distal femur fracture and 106.5° in patients with proximal tibia fracture. Average knee society score was 82.35 points in patients with distal femur fracture and 88.55 points in patients with proximal tibia fracture. Average function score was 80.25 points in patients with distal femur fracture and 87 points in patients with proximal tibia fracture (Table 4).

Table 3: Mean time required for union of fractures

Period in weeks	Distal femur fracture	Distal femur fracture (%)	Proximal tibia fracture	Proximal tibia fracture (%)
12	8	20.00	9	22.50
12–20	9	22.50	10	25.00
20–28	1	2.50	0	0.00
>28	2	5.00	1	2.50
Total	20	100	20	100

Table 4: Range of knee flexion, knee society score, and functional score in studied cases

Range of knee flexion, knee society score, and functional score	Distal femur fracture	Distal femur fracture (%)	Proximal tibia fracture	Proximal tibia fracture (%)
Range of knee flexion in degree				
<30	1	2.50	1	2.50
31–60	1	2.50	1	2.50
61–90	10	25.00	2	5.00
91–120	5	12.50	8	20.00
>120	3	7.50	8	20.00
Total	20	50	20	50
Knee society score				
80–100	13	32.50	17	42.50
70–79	4	10.00	1	2.50
60–69	3	7.50	2	5.00
<60	0	0.00	0	0.00
Total	20	50	20	50
Functional score				
80–100	10	25.00	15	37.50
70–79	6	15.00	3	7.50
60–69	3	7.50	1	2.50
<60	1	2.50	1	2.50
Total	20	50	20	50

Table 5: Shortening of femur and tibia in studied cases

Shortening in cm	Distal femur fracture	Distal femur Fracture (%)	Proximal tibia fracture	Proximal tibia Fracture (%)
0	13	32.50	17	42.50
<0.5	3	7.50	2	5.00
0.6–1.0	2	5.00	1	2.50
1.1–1.5	2	5.00	0	0.00
Total	20	50	20	50

The analysis of the patients on the basis of shortening of femur showed that in 13 (32.50%) patients with distal femur fractures, there was no shortening whereas in 17 (42.50%) patients with proximal tibial fractures, there was no shortening. Among patients with distal femur fracture, 3 (7.50%) patients showed shortening of <0.5 cm whereas shortening of 0.6–1.5 cm was seen in 4 (10%) patients. Similarly, among patients with proximal tibial fractures, 2 (5%) patients showed shortening <0.5 cm and one patient showed shortening of 0.6–1 cm (Table 5).

Table 6: Associated fractures in patients with proximal tibia fractures

Associated fracture	Procedure	Number	Percentage
Femur middle 1/3 shaft fracture	Interlocking nail	2	5.00
Colle's fracture	Colle's cast	1	2.50
Distal femur fracture	Open reduction internal fixation with locking plate	2	5.00
Total		5	12.50

Table 7: Procedures done in cases with proximal tibial fractures

Procedure done	Number	Percentage
Initial debridement	2	5.00
Secondary bone grafting	1	2.50
Plate removal	1	2.50
Total	4	10.00

Table 8: Procedure done for associated injuries with distal femur fracture

Associated fracture	Procedure	Number	Percentage
Tibia middle 1/3 shaft fracture	Interlocking nail	2	5.00
Colle's fracture	Colle's cast	1	2.50
Proximal tibia fracture	Open reduction internal fixation with locking plate	2	5.00
Proximal tibia fracture (B1)	Cannulated cancellous screw fixation	1	2.50
Total		6	15.00

Table 9: Additional procedure done for distal femur fracture

Procedure done	Total number	Percentage
Initial debridement	6	15.00
Secondary bone grafting	2	5.00
Plate removal	1	2.50
Debridement for deep infection	2	5.00
Total	11	27.50

The analysis of the patients with proximal tibia fractures for associated fractures showed that 2 (5%) patients also had femur middle 1/3rd shaft fracture. Two (5%) patients had distal femoral fractures whereas one patient was having Colle's fractures. For femur shaft fracture, interlocking nailing was done whereas open reduction and internal fixation with locking plating was done in distal femur fracture. Colle's fracture was treated by Colle's cast (Table 6).

Initial debridement was required in 2 (5%) patients. One (2.5%) patient with proximal tibia fracture required secondary bone grafting. Plate was removed in 1 (2.5%) patient with late deep infection after bony union (Table 7).

The analysis of the patients with distal femur fractures for associated fractures showed that 2 (5%) patients also had tibia middle 1/3rd shaft fracture. Three (7.5%) patients had proximal tibia fractures whereas one patient was having Colle's fractures. For tibia shaft fracture, interlocking nailing was done whereas open reduction and internal fixation with locking plating was done in 2 (5%) patients with proximal tibia fracture. Cannulated cancellous screw fixation was done in 1 (2.5%) patient with proximal tibia fracture (Table 8).

Initial debridement was required in 6 (15 %) patients. Two (5%) patient required secondary bone grafting. Plate was removed in 1 (2.5%) patient and debridement for deep infection was done in 2 (5%) patients (Table 9).

There were significant differences in the range of flexion, knee society score, and functional score of intra-articular fractures of distal femur versus extra-articular fracture of distal femur treated with locking plate. Results were more favorable in extra-articular fracture as compared to intra-articular fracture of distal femur treated with locking plate. There were no statistically significant differences in the range of flexion, knee society score, and functional score of partial articular and intra-articular fractures of proximal tibia versus extra-articular fracture of proximal tibia treated with locking plate (Table 10).

There were three cases with non-union, all of them united after secondary bone grafting. Superficial infection was seen in total of two patients. Three patients had deep infection. Four patients had plate irritation. Superficial infection was seen in patient with proximal tibia fracture AO type C3 with known case of diabetes mellitus. The wound healed eventually with continued dressing and antibiotics. Non-union and bent plate was seen in patient with distal femur fracture AO type C2 (Fig. 2).

DISCUSSION

In our study, most of the patients of proximal tibia fracture and distal femur fracture were of young age group. The mean age for the patients with distal femur fractures was 42.25 years, and for the proximal tibia fractures, it was 40.55 years. Krupp *et al*. conducted a study of

Table 10: Comparison of intra-articular versus extra-articular fractures of distal femoral and proximal tibia fractures operated with locking plate

Particular	Intra-articular fracture	Extra-articular fracture	Unpaired t-test	p-value
Distal femoral fractures				
Range of flexion	77±12.95	100±30.36	−2.203	0.040 (significant)
Knee society score	75.4±9.29	89.3±12.02	−2.89	0.009 (significant)
Functional score	71.5±9.14	89±15.05	−3.14	0.005 (significant)
Proximal tibial fractures				
Range of flexion	103.5±21.73	109.5±30.68	−0.5046	0.61 (not significant)
Knee society score	85.8±11.25	91.3±11.43	−1.08	0.29 (not significant)
Functional score	83.0±12.95	91.0±11.73	−1.44	0.16 (not significant)

58 consecutive bicondylar tibial plateau fractures at a Level I trauma center [8]. All bicondylar tibial plateau fractures were classified as Schatzker V/VI or AO/OTA type 41C. Twenty-eight patients in one group were treated using a locked plating system, and 30 patients in another group were treated with a hybrid or circular external fixation frame. The 2 groups were similar demographically. The Schatzker VI subgroup accounted for 25 of the 27 complications (93%) in the locked plating group and 40 of the 48 complications (83%) in the external fixation group. The mean age of the patients in this study was found to be 47 years which was similar to mean age in our study. Similar mean age of the patients was also reported by the authors such as Nayak *et al*. [9] and Gosling *et al*. [10].

We have classified proximal tibia fractures according to AO classification. Most common fracture were A3 type and C2 type both were 7 in numbers each, contributing to total of 70% of all proximal tibia fractures. A2 type were 3 (15%) in numbers, followed by B3, C1, C3 each one in number. One proximal tibia fracture AO type B1, associated with distal femur fracture, was treated with cannulated cancellous screw, not included in our study. Our results are comparable with Ha *et al*. [11]. In study by Christian Boldin *et al*. [12], 10 fractures were extra-articular and 16 were intra-articular. Similarly, we have used AO classification for distal femur fractures. Both intra and extra-articular fractures were equal in number. Most common type was C3; six in number contribute to 30% of cases, followed by C2 and A3 20% each and A1 and A2 15% each. Our incidence is similar to study by Sie *et al*. [13] and Yeap and Deepak *et al.* [14]. In the study by Weight and Collinge out of 26 distal femur fractures, all were comminuted; according to the AO/OTA fracture classification, there were four A2, three A3, 12 C2, and three C3 fractures [15].

Fig. 1: Pre-operative X-ray showing extra-articular right side distal femur fracture AO type A2 (Upper left and right) and post-operative X-rays showing surgical treatment by plates (Lower left and right)

In our study, most of the patients of extra-articular fractures of distal femur had good range of movements. There was no significant difference in range of movements of intra-articular or extra-articular fractures of proximal tibia. Gross restriction of movements, <50°, occurred in two patients with ipsilateral fracture of distal femur and proximal tibia, both were treated with locking plate. The mean range of knee flexion in distal femur fractures was less (88.5°) as compared to proximal tibia fractures which was 106.5°. In a similar study, Neer *et al*. concluded that with the exception of the linear, non-displaced fractures, and supracondylar fractures always resulted in some impairment of the terminal ranges of flexion. The recovery of motion was more complete in Group Il-B than in Group Il-A while in Group III recovery was still more imperfect. This loss of motion was thought to reflect the extent of damage to the quadriceps accompanying each type of injury [16].

Out of 20 distal femur fractures, 13 fractures showed radiological union at 12–14 weeks. Two distal femur fractures went into non-union, additional procedure of secondary bone grafting was done in one patient at 28 weeks, and in one patient, bent plate was removed and fixation with long locking plate with secondary bone grafting done at 28 weeks which eventually united radiologically at 34 weeks. Most of the fractures united at 12–14 weeks (65%), 4 united at 20 weeks, and one united at 26 weeks. In our study, 70% of fractures of proximal tibia fractures united at 12–14 weeks, followed by 25% at 18–20 weeks, one went into aseptic non-union which was further treated by secondary bone grafting and united at 34 weeks. In a study by Kanabar *et al*., mean time of union for distal femur fractures was 17 weeks, similar to our result [17]. Fourteen patients attained bone union in a mean period of 17 (range, 10–36) weeks. Delayed union was observed radiographically in a 73-year-old man, though he was clinically asymptomatic and mobile. The fracture eventually united at 9-month follow-up. Two patients had non-union due to implant loosening and underwent re-less invasive stabilization system (LISS) plating and bone grafting with satisfactory final outcomes. In a study by Boldin *et al*., out of 26 proximal tibia fractures, 25 got united without additional procedure [12]. One fracture got united after secondary bone grafting. Average period of radiological union was 11 weeks and ranged from 8 to 25 weeks.

In our study, final outcome at the end of 1 year was derived using knee society score and functional score. Grading was done as excellent, good, fair, and poor according to knee society score. Thirteen patients of distal femur fracture had excellent knee society score (KSS), 4 – good and 3 – fair. Out of 20 proximal tibia fractures, 17 patients had excellent

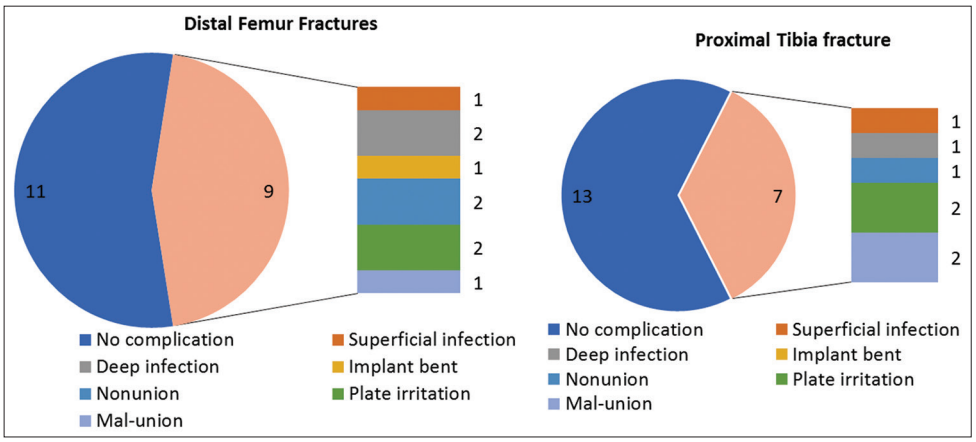

Fig. 2: Complication in distal femoral and proximal tibial fractures

knee society score, one patient had good society score, and two had fair. Our results are comparable with study by Haidukewych *et al*. [18] and Nikolaou *et al*. [19].

CONCLUSION

Proper implementation of bio-mechanics of locking plate gives excellent functional outcome of fractures around knee surgically treated with locking plate and locking plate allows good angular stability in distal femur fractures and proximal tibia fractures.

AUTHORS CONTRIBUTION

VK - Concept and design of the study, interpreted the results, prepared first draft of manuscript, and critical revision of the manuscript; AW - Statistically analyzed and interpreted, reviewed the literature, and manuscript preparation; SH - Design of the study, statistically analyzed and interpreted, preparation of manuscript, and revision of the manuscript.

ACKNOWLEDGMENT

The authors would like to acknowledge the assistance extended by faculties and staff of Department of Orthopaedics JIIU's IIMSR MEDICAL College, warudi badnapur, Maharashtra, India, in undertaking this study.

CONFLICTS OF INTEREST

None.

REFERENCES

1. Bertrand ML, Andrés-Cano P, Pascual-López FJ. Periarticular fractures of the knee in polytrauma patients. Open Orthop J 2015;9:332-46. doi: 10.2174/18743250 01509010332. PMID: 26312118; PMCID: PMC4541416
2. Rohra N, Suri HS, Gangrade K. Functional and radiological outcome of Schatzker Type V and VI tibial plateau fracture treatment with dual plates with minimum 3 years follow-up: A prospective study. J Clin Diagn Res 2016;10:RC05-10. doi: 10.7860/JCDR/2016/18732.7855
3. De Mesquita Paiva M, Leal DP, Kuroki PK, Barroso BG, Reyna MA, de Camargo Leonhardt M, *et al*. Distal femoral fractures from high-energy trauma: A retrospective review of complication rate and risk factors. Acta Ortop Bras 2022;30:e256896. doi: 10.1590/1413-785220223002e256896
4. Varga P, Grünwald L, Inzana JA, Windolf M. Fatigue failure of plated osteoporotic proximal humerus fractures is predicted by the strain around the proximal screws. J Mech Behav Biomed Mater 2017;75:68-74. doi: 10.1016/j.jmbbm.2017.07.004. PMID: 28697401
5. Gahr P, Kopf S, Pauly S. Current concepts review. Management of proximal tibial fractures. Front Surg 2023;10:1138274. doi: 10.3389/fsurg.2023.1138274. PMID: 37035564; PMCID: PMC10076678
6. Siddiqui YS, Mohd J, Abbas M, Gupta K, Khan MJ, Istiyak M. Technical difficulties and mechanical failure of distal femoral locking compression plate (DFLCP) in management of unstable distal femoral fractures. Int J Burns Trauma 2021;11:9-19. PMID: 33824780; PMCID: PMC8012867
7. Parekh AA, Smith WR, Silva S, Agudelo JF, Williams AE, Hak D, *et al*. Treatment of distal femur and proximal tibia fractures with external fixation followed by planned conversion to internal fixation. J Trauma 2008;64:736-9. doi: 10.1097/TA.0b013e31804d492b
8. Krupp RJ, Malkani AL, Roberts CS, Seligson D, Crawford CH 3rd, Smith L. Treatment of bicondylar tibia plateau fractures using locked plating versus external fixation. Orthopedics 2009;32:5242-4. doi: 10.3928/01477447-20090624-11
9. Nayak RM, Koichade MR, Umre AN, Ingle MV. Minimally invasive plate osteosynthesis using a locking compression plate for distal femoral fractures. J Orthop Surg (Hong Kong) 2011;19:185-90.
10. Gosling T, Schandelmaier P, Muller M, Hankemeier S, Wagner M, Krettek C. Single lateral locked screw plating of bicondylar tibial plateau fractures. Clin Orthop Relat Res 2005;439:207-14.
11. Ha SH, Kim DH, Lee JY. Treatment of proximal tibia fractures using LCP by MIPO technique. J Korean Fract Soc 2010;23:34-41.
12. Boldin C, Fankhauser F, Hofer PH, Szyszkowitz R. Three-year results of proximal tibia fractures treated with the LISS. Clin Orthop Relat Res 2006;445:222-9.
13. Sie EJ, Mobiot CA, Traore A, Lambin Y. Distal femoral fractures treated with condylar buttress plate in a West African hospital. J Clin Orthop Trauma 2012;3:98-102.
14. Yeap EJ, Deepak AS. Distal femoral locking compression plate fixation in distal femoral fractures: Early results. Malays Orthop J 2007;1:12-7.
15. Weight M, Collinge C. Early results of the less invasive stabilization system for mechanically unstable fractures of the distal femur (AO/OTA types A2, A3, C2, and C3). J Orthop Trauma 2004;18:503-8. doi: 10.1097/00005131-200409000-00005
16. Neer CS 2nd, Grantham SA, Shelton ML. Supracondylar fracture of the adult femur. A study of one hundred and ten cases. J Bone Joint Surg 1967;49:591-613.
17. Kanabar P, Kumar V, Owen PJ, Rushton N. Less invasive stabilisation system plating for distal femoral fractures. J Orthop Surg (Hong Kong) 2007;15:299-302.
18. 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;89:614-20.
19. Nikolaou VS, Tan HB, Haidukewych G, Kanakaris N, Giannoudis PV. Proximal tibial fractures: Early experience using polyaxial locking-plate technology. Int Orthop 2011;35:1215-21.