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Original Research Article

# A COMPARATIVE STUDY ON BI-COLUMNAR VERSUS LATERAL PLATING OF DISTAL FEMUR FRACTURES IN POST POLIOMYELITIS PATIENTS

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ABSTRACT

**Background:** The complex skeletal deformities and the fractures in polio survivors remains as a big challenge to the orthopaedic surgeons of this era. Distal femur fractures in the polio patients are more challenging due to osteoporosis, inadequate fixation due to very short distal fragment, poor blood supply and deformities. Due to relatively low failure rates, anatomical locked plating becomes one of the best options for treating distal femur fractures. However single lateral plating in such fractures often leads to relatively higher failure rate. Medial plating in addition to lateral plating reduces the chances of failure of fixation. The purpose of this study is to compare the functional as well as radiological outcomes between dual plating versus the single lateral plating of distal femur fractures in post poliomyelitis patients.

**Materials and Methods:** We included 14 patients with 14 fractures in our study out of which 2 cases were lost to follow up. Finally, 12 patients were included in this study which was divided into two groups. Group A consists of patients treated with single lateral plating while group B included patients with dual plating. The range of movement of the knee after bony union of the fracture, fracture union time, time to weight bearing, post operative stay in hospital, duration of surgery, intraoprative blood loss, infection, implant failure, time to return to daily activities and HSS Score were assessed.

**Results:** Bony union of the fracture was seen between 18–24 weeks although union time was longer in single lateral plating group. There was one case of delayed union and one implant failure which were managed with dual plating and bone grafting. None of our patients had infection or non-union.

**Conclusion:** According to this study in distal femur fractures in post-polio residual paralytic limbs, the fracture healing process is poor as compared to normal bone. The surgical planning and intervention is quite challenging. After reduction of the fracture, maintaining it by a stable fixation with proper implants is of paramount importance. We found dual plating of the fracture was functionally and anatomically superior to single lateral plating.

**Keywords:** Bi-columnar plating, distal femur fracture, post-polio residual paralytic limb, Hospital for Special Surgery (HSS) knee score

## INTRODUCTION

Poliomyelitis leads to asymmetrical flaccid paralysis which leads to deformities and disabilities as sequelea owing to infection of polio virus involving the anterior horn cells of the neurons.[1-3] It causes muscle atrophy which gives rise to bony deformity and reduced stability and mobility. This causes altered gait pattern and predisposes to frequent falls.[4] The quadriceps muscles are affected when the

lower limbs are involved leading to weakness and buckling of knee in stance phase of the gait cycle which becomes a risk factor for frequent falls and fractures. Also failure to clear the foot off the ground during swing phase due to paralysis of ankle dorsiflexor and or hip flexor contributes to frequent falls and fractures.[3] In a study conducted by Bickerstaffe et al. in 2010 amongst 305 polio patients, it was found that 74% had at least one fall in the past 1 year and 60% had two or more falls.[4] Then distal femur and proximal humerus are the most common bones to be featured in polio patients.[5] Distal femoral fracture in elderly population poses huge complexities and challenges in its management due to poor bone quality,[6] especially in post-poliomyelitis patients. Besides the poor bone quality in post-polio patients,[5,7,8] the affected bones are usually hypoplastic, deformed and hypovascular as a result of decreased bulk of muscles and poor blood supply to it. These factors lead to poor fracture healing.[9-11] The rehabilitation process is hampered due to muscular weakness and restricted ambulation of the patients.[5] Distal femoral fractures in the elderly are associated with poor bone quality, short distal fracture fragment which impedes stable fixation, blood loss, non-union ,mal union, and implant failure,[12-14] which becomes more pronounced with post poliomyelitis patients. Locking compression plates (LCPs) are commonly used for fixation of distal femoral fractures in osteoporotic bones as those provide angular stability by minimizing interference with the fracture site.[15,16] A retrospective study on post-polio patients, involving fractures in the proximal part, mid shaft and distal part of the femur, has shown that LCPs may provide good functional outcomes.[17] Another study shows that single lateral plating of distal femur fractures have a relatively higher failure rate.[18] Medial plating is found to reduces the chances of failure of fixation if it is done in addition to lateral plating.[18] We used 4.5mm locking recon plate for medial side and anatomical locking plate for lateral side.

The post-polio distal femur fractures require a complex surgical planning and challenging fixation procedure. Difficulty is faced at every step in obtaining anatomic reduction, selection of suitable implants, fracture union and rehabilitation. Paucity of literatures about fixation of such fractures and comparison of single plating versus dual plating unique bony deformities and difficulties in management of such fractures has encouraged us to conduct this study. The aim of this study is to compare the range of movement of the knee after bony union of the fracture, fracture union time, time to weight bearing, total stay in hospital, duration of surgery, intraoprative blood loss, infection, implant failure, time to return to daily activities and HSS Score.

## MATERIALS AND METHODS

This study was a prospective study conducted upon distal femur fractures in post-polio patients between January 2021 to December 2024 in our institute which included 14 patients (10 males &4 females) who sustained unilateral distal femur fractures & were treated with ORIF. The age group of patients varied from 22 years to 65 years. Two out of fourteen patients were lost to follow up which included one male and one female. Therefore, 12 patients were included in the study finally which contained 9(75%) male and 3(25%) females. The age & sex distribution of patients included in the study is shown in Table 1.

**Table 1: Showing age & sex distribution of patients included in the study**

| Age group | Male | Female |
|---|---|---|
| 20-30 | 2 | 0 |
| 30-40 | 3 | 1 |
| 40-50 | 2 | 1 |
| 50-60 | 1 | 0 |
| >60 | 1 | 1 |

Seven patients were treated with unicondylar anatomical locking compression plate and were grouped into group A. Similarly, five patients who underwent bi-columnar plating were allocated into group B. The causes of fractures were road traffic accidents (7 patients) and house hold fall (3 patients), fall from bicycle (2 patients). Fractures were classified (Association for Osteosynthesis /Orthopaedic Trauma Association classification) as 32-B2 in two patients, 32-B3 in one, 32-C3 in one, 33-A1 in two, 33-A2 in one, 33-B1 in three and 33-C1 in two cases (Figure 1). Surgery was performed after improvement of the general condition of the patients and after the local swelling subsided.

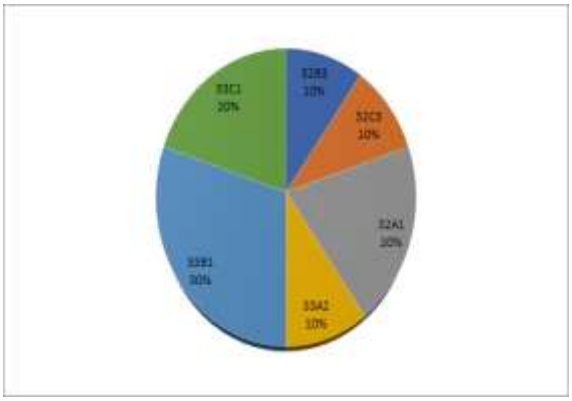

**Figure 1: Showing AO-OTA classification of fractures**

Only closed distal femur fractures involving post-polio limbs were included in the study(Figure-2a). Compound fractures, poly trauma patients, patients without consents, patients with major co morbid conditions, patients having previous fracture in the same polio affected limbs; patients below 22 years and above 65 years of age were excluded from our study.

The lateral side was fixed with anatomical locking plate and contoured 4.5 mm locking reconstruction plate was used when additional medial plating was done (Figure 2b). The procedure was conducted without using tourniquet. Lateral par patellar, lateral and direct medial approach were adopted. The length of the lateral plate was chosen in such a way that at least 4 screws could be accommodated in the proximal fragment. The medial plate was applied in a buttress manner (Figure 2b). The plates were applied in sub muscular planes. Due to hypo plastic and deformed femur contouring of the anatomical plate was required in maximum cases.

The patients were followed up at 6 weeks, 3 months, 6 months and 1 year after surgery for radiological and functional evaluation.

Antero posterior and lateral radiographs of the distal femur were taken to evaluate the callus formation and fracture union in each follow up. Bony union was defined as formation of bridging callus in three out of four cortices on orthogonal radiographs and solid union was considered when cross trabeculations were visible on anteroposterior and lateral radiographs.

After achieving bony union of the fractures, the patients were evaluated for functional outcomes in the affected limb in terms of range of motion, time to return to daily activities and Hospital for Special Surgery (HSS) knee score.

Additionally, the duration of surgery, total blood loss during surgery, infection and implant failure were documented to compare between the two study groups.

**Figure 2: (a) Represents pre-operative X-ray, (b) Represents immediate post-operative X-ray after bi-columnar plating (c) Represents post-operative X-ray of bi-columnar plating after 6 weeks (d) Represents post-operative X-ray of bi-columnar plating after 6 months**

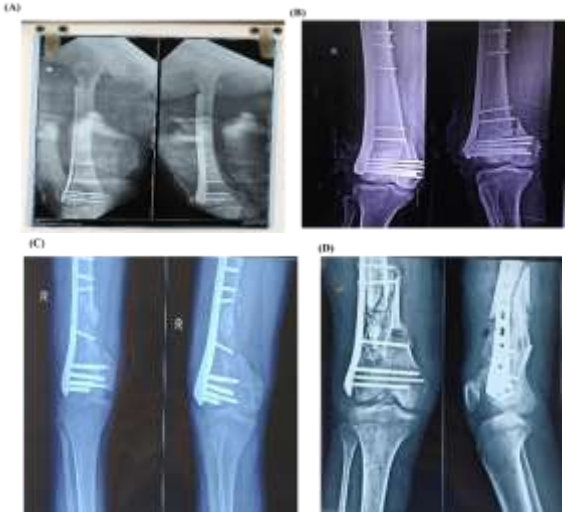

**Figure 3: (a) Represents X-ray showing immediate post op X-ray of lateral plating, (b) represents X-ray showing inadequate fixation with delayed union after 6 months (c) represents X-ray showing Impending implant failure and varus collapse due to weak medial column and no plating on medial side (d) represents X-ray showing progressive varus collapse in Unicolumnar lateral plating due to lack of medial support**

## RESULTS

Bony union of the fracture was seen between 18–24 weeks (Figure 3d). Although union time was longer in single lateral plating group. There was one case of delayed union (Figure 2b) and one implant failure which were managed with dual plating and bone grafting. None of our patients had infection or non-union.

Mean duration of surgery was 95.5 mins (range 65-126 mins) in group A vs 112 mins in group B (range 80-138 mins) (P value-0.1001- non significant).

Mean intraoperative blood loss was 115 ml (range 50-180 ml) in Group A vs 170 mL (range 90–250 mL) in group B (P value-0.0258-significant). Mean postoperative hospital stay was 4.5days in group A (range 3–6 days) 5 days in group B patients (range 4–6 days) (P value-0.2258-non significant). Average knee flexion before discharge was around 70 degree in Group A and 60 degree in group B (P value-0.006595-significant) which may be attributed to postoperative pain. The flexion achieved in final follow up was 100 degrees in group A vs 110 degrees in group B (P value- 0.00782- significant). Mean time taken for union of fracture was 255 days in group A (range 200-310 days) vs 170 days in group B (range 110 -230 days) (P value-0.0004- significant). Mean time to return to pre trauma activity level in group A was 85 days & group B was 72 days (P value-0.09219- not significant). One patient from group A went on to delayed union and another into implant failure which were revised (bone graft +dual plating) later. Mean HSS score was 71 (range 58-84) in group A vs 80.5 (range 65-96) in group B (P value-0.04359-significant) at final follow up. [Table 2] From group A, one patient developed medial collapse and one developed implant failure. There was no case of surgical site infection or non union in either group.

**Table 2: Comparative Surgical Outcomes**

| | Group A-Range (mean) | Group B-Range (mean) | P Value |
|---|---|---|---|
| Surgery time(min.) | 65-126(95.5) | 80-138(112) | 0.1001 |
| Blood loss(ml.) | 50-180(115) | 90-250(170) | 0.0258 |
| Post-op stay(days) | 3-6(4.5) | 4-6(5) | 0.2258 |
| Knee flexion on discharge(deg.) | 70 | 60 | 0.006595 |
| Knee flexion on final follow up(deg.) | 100 | 110 | 0.0082 |
| Time to union(days) | 200-310(255) | 110-230(170) | 0.000417 |
| Time to return to daily activity(days) | 85 | 72 | 0.09219 |
| HSS Score | 58-84(71) | 65-96(80.5) | 0.04359 |

## DISCUSSION

There is very little literature available on the management of femoral fractures in post polio patients. Therefore, the management of such fractures becomes very challenging. Early fixation and mobilization in such cases is of paramount importance. Prolonged casting and immobilization in these patients may worsen the poor bone quality and joint contracture and may be associated with complications such as bed sores and non-union.[18] Mohammad et al. reported that their outpatient post-polio patients had osteopenia or osteoporosis in 96% and 38% of their patients had experienced a fracture at a 5-year follow-up.[8] In another study in polio survivors it was found that 61% of 233 community-based participants had falls for which they needed medical care, including 35% who had sustained a fracture.[19] Usually most of the post-polio extremities have small and deformed bones. A polio-affected extremity is a risk factor for disuse osteoporosis.[19] As compared to the general population the prevalence of osteopenia and osteoporosis is much more prevalent in polio-affected extremities.[4] The incidence of fracture in aging post-polio patients ranges from 28% to 38%; they occur predominantly on the side of polio involvement.[8,19] In polio patients, the fractures commonly occur in the distal femur and proximal humerus.[5] The high incidence of fracture in post-polio patients may be due to frequent falls during daily life activities which is around 64% within 1 year and 79%–82% over 5 years.[8,19]

The surgical management of distal femoral fractures of post-polio patients is much more difficult than in normal patients. Although in our study, the patients had weakness in the affected limbs, significantly higher traction force was required during reduction of fracture, probably due to tissue contracture.[20,21] Moreover the thin cortical bone, increased the risk of further comminution from the reduction instruments. In order to minimize soft tissue stripping and disruption of the blood supply, the primary goal of reduction was functional alignment and not anatomic reduction. This may result in longer operative times and increased intra-operative blood loss than in the general population.[15,16]

There are various options of implants available for reduction and fixation of distal femoral fractures like condylar blade plates, intramedullary nails, external fixation devices etc. Blade plates require large incisions and direct compression of the plate on bone, which may jeopardize the blood supply at the fracture site. Although, intramedullary nails with multiple distal locking screws, improve stability of distal fracture fragment and require minimal incision,[22] these are relatively contraindicated for comminuted fractures such as intercondylar fractures (type 33-C) or post-polio patients with deformity and small femoral shafts and medullary cavities.[9-11] Moreover the flexion deformity of the knee may interfere with proper entry of nails.[20,21] Due to the deformity of polio affected femur, meticulous contouring of the lateral and medial plate had to be done to achieve possible and proper reduction.

In one study, surgical management of 13 femoral fractures in post-polio patients with LCPs resulted in radiographic union in 12 fractures by 12 to 20 weeks after surgery and return to the same level of disability at the end of follow-up as before occurrence of the fracture; only one patient had non union with a decreased disability score and daily walking time.[17] However, the previous study had also included the proximal femoral fractures,[17] whereas in the present study, we included only distal femoral fractures and we used LCPs alone or in combination with medial

plating by contoured reconstruction plates (Figure 3b). The results of our study are corroborated with those of the previous study that LCPs result in satisfactory union and functional outcomes in post-polio patients with distal femoral fractures.[17]

Although LCPs provide excellent stability,[23] previous studies have showed that these are too rigid to allow for micro motion at the fracture site in response to axial loading.[24,25] In a systematic review of distal femoral fractures (excluding periprosthetic fractures) treated with LCPs, complications included non union (0%– 19%), delayed union (0%–15%) and implant failure (0%– 20%).[23] In spite of compromised vascularity of the bone and muscles inpost-polio patients which potentially increases the risk of these complications, non-union and infection did not occur in the present study although delayed union and implant failure occurred in the patients of group A (Figure 3c and 3d). Implant failure may be due to weaker implant anchorage over osteoporotic bone of distal femur in polio affected limb which leads to screw cut out or collapse of the medial column (Figure 3d).[7,8] There is extensive metaphyseal comminution and osteoporotic bone in distal femur fractures which leads to functional loss of medial cortical buttress and poor bone healing of the medial column. The addition of a medial plate provides additional stability and reduces the chances of implant failure.[12,26] There is an increased risk of non-union or delayed union in patients with comminute distal femur fractures treated with single lateral locking plate.[27] There is a high incidence of failure of fixation when a single lateral plate is used in distal femur fracture with osteoporotic bone due to poor purchase of screw in osteoporotic bone. In a study conducted by Metwaly et al it was shown that dual plating in osteoporotic distal femur fractures offers a stable fixation, early mobility and early rehabilitation.[28] Steinberg et al. also showed that higher union rate occurs with dual plating in fractures with osteoporotic bone.[13] In patients with AO type C3 distal femoral fractures, dual plating provides more stable fixation. Imam et al. demonstrated that dual plating fixation in type C3 distal femoral fractures has several advantages such as precise exposure, easy manipulation, anatomical reduction, and stable fixation.[12] El Beaino et al. in their study found that dual locking plates had higher torsional stiffness than conventional non-locking plates.[29] Orthogonal plate configuration was used in our study because such configuration imparts more stable fixation and is biomechanically superior to dual adjacent plating for constructs fixed with either standard compression or locking plates.[29] The use of locking compression plates in femoral fractures of polio-affected extremities is beneficial because they may be contoured to the non-anatomic shape of the bone and are indicated in osteoporotic or disused bone.[17]

In a comparative study of single vs. dual plating in distal Femur Fracture in normal individuals, the mean union time was 24.5 ± 3.035 weeks in the single plating group and 21.4 ± 2.761 weeks in the dual plating group which correlates well with our results (255 days vs 170 days). They found that dual plating group showed better functional results than the single plating group according to the knee society score. Comparing the range of motion, the dual plating group showed excellent results like our study (mean of 100 degrees in group A vs 110 degrees in group B).[30] However, we were not able to find any article which compared these results in polio affected limbs. Limitations of the present study include the small sample size, which couldn't allow us to analyse separately the outcomes of intra- and extra-articular fractures, limited options of implants used in this study and the absence of a control group.

## CONCLUSION

The distal femur fractures in post poliomyelitis patients are commonly associated with difficulties in fracture reduction & fixation, delayed union, non union, bony deformity, small bones, contractures of muscles and osteopenia. A stable, anatomic and biological fixation which can be possible by using anatomic locking plates (LCPs) may enable the patients to start early range of motion and weight bearing which helps in their accelerated rehabilitation. As, such fractures are often comminuted and the bone quality is quite poor due to pre-existing osteoporosis, the medial column of the distal femur is very weak and is prone to non union and collapse. To deal with this problem, we used dual column plating in an orthogonal configuration in which the medial side was fixed by a buttressing plate. This resulted in faster bony union, less chance of delayed union/ non union, less chance of implant failure, more range of motion of knee due to better rehabilitation and early return to pre fracture life activities. We are of the opinion based upon the finding from our study that bi columnar plating of distal femur fractures in post poliomyelitis patients is a better viable option than single lateral plating to deal with the challenges and peculiarities with such fractures which may produce better functional outcomes . However further studies are required in this aspect to arrive at a standard protocol of management in such factures as there is paucity of literatures available regarding this.

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## REFERENCES

1. Groce NE, Banks LM, Stein MA. Surviving polio in a post-polio world. Social Science & Medicine. 2014 Apr 1; 107:171-8.

2. Haziza M, Kremer R, Benedetti A, Trojan DA. Osteoporosis in a postpolio clinic population. Archives of physical medicine and rehabilitation. 2007 Aug 1;88(8):1030-5.
3. Emara KM, Khames A. Functional outcome after lengthening with and without deformity correction in polio patients. International Orthopaedics. 2008 Jun;32(3):403-7.
4. Bickerstaffe A, Beelen A, Nollet F. Circumstances and consequences of falls in polio survivors. Journal of rehabilitation medicine. 2010 Nov 1;42(10):908.
5. Goerss JB, Atkinson EJ, Windebank AJ, O'FALLON WM, MELTON III LJ. Fractures in an aging population of poliomyelitis survivors: a community-based study in Olmsted County, Minnesota. InMayo Clinic Proceedings 1994 Apr 1 (Vol. 69, No. 4, pp. 333-339). Elsevier.
6. Wähnert D, Hoffmeier K, Fröber R, Hofmann GO, Mückley T. Distal femur fractures of the elderly—different treatment options in a biomechanical comparison. Injury. 2011 Jul 1;42(7):655-9.
7. Chang KH, Lai CH, Chen SC, Tang IN, Hsiao WT, Liou TH, Lee CM. Femoral neck bone mineral density in ambulatory men with poliomyelitis. Osteoporosis international. 2011 Jan;22(1):195-200.
8. Mohammad AF, Khan KA, Galvin L, Hardiman O, O'Connell PG. High incidence of osteoporosis and fractures in an aging post-polio population. European neurology. 2009 Nov 1;62(6):369-74.
9. Lloyd ME, Spector TD, Howard R. Osteoporosis in neurological disorders. Journal of Neurology, Neurosurgery & Psychiatry. 2000 May 1;68(5):543-7.
10. Sharrard WJ. Paralytic deformities of the lower limb. International orthopaedics. 1984 Sep;8(2):147-54.
11. Shim SS. Bone and Joint Circulation Physiological Basis for Clinical Practice. Yonsei Medical Journal. 1986 Jun 1;27(2):91-9.
12. Imam MA, Torieh A, Matthana A. Double plating of intra-articular multifragmentary C3-type distal femoral fractures through the anterior approach. European Journal of Orthopaedic Surgery & Traumatology. 2018 Jan;28(1):121-30.
13. Steinberg EL, Elis J, Steinberg Y, Salai M, Ben-Tov T. A double-plating approach to distal femur fracture: a clinical study. Injury. 2017 Oct 1;48(10):2260-5.
14. Meneghini RM, Keyes BJ, Reddy KK, Maar DC. Modern retrograde intramedullary nails versus periarticular locked plates for supracondylar femur fractures after total knee arthroplasty. The Journal of Arthroplasty. 2014 Jul 1;29(7):1478-81.
15. Fulkerson E, Egol KA, Kubiak EN, Liporace F, Kummer FJ, Koval KJ. Fixation of diaphyseal fractures with a segmental defect: a biomechanical comparison of locked and conventional plating techniques. Journal of Trauma and Acute Care Surgery. 2006 Apr 1;60(4):830-5.
16. Stoffel K, Dieter U, Stachowiak G, Gächter A, Kuster MS. Biomechanical testing of the LCP--how can stability in locked internal fixators be controlled?. Injury. 2003 Nov 1;34:B11-9.
17. El-Sayed Khalil A. Locked plating for femoral fractures in polio patients. Archives of orthopaedic and trauma surgery. 2010 Oct;130(10):1299-304.
18. Versluysen M. How elderly patients with femoral fracture develop pressure sores in hospital. Br Med J (Clin Res Ed). 1986 May 17;292(6531):1311-3.
19. Silver JK, Aiello DD. Polio survivors: falls and subsequent injuries. American journal of physical medicine & rehabilitation. 2002 Aug 1;81(8):567-70.
20. Zouari O, Gargouri A, Jenzri M, Hadinane R, Slimane N. Supracondylar femoral extension osteotomy for knee flexion contracture correction in poliomyelitic conditions. Revue de Chirurgie Orthopedique et Reparatrice de L'appareil Moteur. 2001 Jun 1;87(4):361-6.
21. Asirvatham R, Rooney RJ, Watts HG. Proximal tibial extension medial rotation osteotomy to correct knee flexion contracture and lateral rotation deformity of tibia after polio. Journal of Pediatric Orthopaedics. 1991 Sep 1;11(5):646-51.
22. Wähnert D, Hoffmeier KL, von Oldenburg G, Fröber R, Hofmann GO, Mückley T. Internal fixation of type-C distal femoral fractures in osteoporotic bone. JBJS. 2010 Jun 1;92(6):1442-52.
23. Henderson CE, Kuhl LL, Fitzpatrick DC, Marsh JL. Locking plates for distal femur fractures: is there a problem with fracture healing?. Journal of orthopaedic trauma. 2011 Feb 1;25:S8-14.
24. Marti A, Fankhauser C, Frenk A, Cordey J, Gasser B. Biomechanical evaluation of the less invasive stabilization system for the internal fixation of distal femur fractures. Journal of orthopaedic trauma. 2001 Sep 1;15(7):482-7.
25. Stoffel K, Lorenz KU, Kuster MS. Biomechanical considerations in plate osteosynthesis: the effect of plate-to-bone compression with and without angular screw stability. Journal of orthopaedic trauma. 2007 Jul 1;21(6):362-8.
26. Gwathmey WF, Jones-Quaidoo SM, Kahler D, Hurwitz S, Cui Q. Distal femoral fractures: current concepts. JAAOS-Journal of the American Academy of Orthopaedic Surgeons. 2010 Oct 1;18(10):597-607.
27. Karam J, Campbell P, David M, Hunter M. Comparison of outcomes and analysis of risk factors for non-union in locked plating of closed periprosthetic and non-periprosthetic distal femoral fractures in a retrospective cohort study. Journal of Orthopaedic Surgery and Research. 2019 May 24;14(1):150.
28. Metwaly RG, Zakaria ZM. Single-incision double-plating approach in the management of isolated, closed osteoporotic distal femoral fractures. Geriatric orthopaedic surgery & rehabilitation. 2018 Nov 5; 9:2151459318799856.
29. El Beaino M, Morris RP, Lindsey RW, Gugala Z. Biomechanical evaluation of dual plate configurations for femoral shaft fracture fixation. BioMed research international. 2019;2019(1):5958631.
30. Shah A, Agarwal S, Nagaich A. Comparative study of single vs. dual plating in distal femur fracture. Journal of Bone and Joint Diseases. 2024 Jan 1;39(1):1-8.