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Novel Method of Tackling Fracture Non-Union

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Abstract:-

- ***Aim:***

To evaluate the novel methods in revision surgery to tackle non-union fractures of different cases of patients.

- ***Background:***

Non-union of bone is the body's inability to heal a fracture. The most agreed-upon standard definition of non -union made by the FDA is a fracture that persists for a minimum of nine months without signs of healing for three months. Non-union fractures of femur pose significant challenges in orthopaedic surgery, often requiring revision procedures to achieve successful bone healing. In cases where the initial implant has failed, innovative solutions are necessary to promote bone union and functional recovery.

- ***Case Description:***

The case report presented with four different geriatric patients had previously undergone implants surgery, which subsequently failed to promote bone healing. The patients were reoperated using a proximal femur nail (PFN) and augmented with a locking compressed plate (LCP) to address the non-union. The combination of the PFN and LCP along with bone graft successfully provided stability to the fracture site, promoting bone union, and enabling functional recovery. Radiographic evidence and clinical assessment demonstrated excellent healing progress.

- ***Conclusion:***

This case study emphasizes the significance of customized care for non-union femur shaft fractures, particularly in cases where implant failure has occurred in the past. When treating difficult non-union fractures, 35mm locking plate and bone graft coupled can be a useful tool for stabilizing the fracture and promoting effective bone healing.

- ***Clinical Significances:***

This case report exemplifies the need for innovative and individualized approaches in the management of challenging non-union femur fractures. Locking compression plates along with PFN and bone graft present a viable method, but further investigation and clinical data are needed to confirm the efficacy and long-term results of this strategy. Even with such complex orthopedic settings, successful outcomes can be attained via meticulous planning and a patient-centered approach. Moreover, to prevent revision, the initial treatment must be the best.

Keywords: *Proximal Femoral Nails (PFN), Locking Compression Plates (LCP), Closed Reduction And Internal Fixation (CRIF), Diabetes Mellitus (DM), Hypertension (HTN), And Chronic Kidney Disease (CKD)*

I. INTRODUCTION

The femur, or thigh bone, is the longest and strongest bone in the human body. It extends from the hip joint at the pelvis to the knee joint. It plays a vital role in weight bearing in the lower extremities. Because of its strength, fracturing the femur typically requires a big force, as that from a fall or an automobile accident. Femur fractures are classified based on the location and pattern of the break, they are; Proximal femur fracture, Femoral shaft fracture and Distal femur fracture.

Femoral shaft fractures, also known as broken thighbone fractures, can occur in the proximal femur and can be classified as spiral or transverse. The proximal segment of the femur is often pulled into flexion and external rotation by the psoas muscle and abduction by the abductors. Spiral or transverse are the most common types of femoral shaft fractures. Femoral shaft fractures can be caused by trauma, such as a direct hit to the thigh or an indirect force transmitted through the knee. Orthopaedic physicians treat femur shaft fractures more frequently than any other type of injury. These fractures are potentially fatal and frequently accompany polytrauma[1]. They frequently arise from high-energy events like auto accidents, and if left untreated, can cause limb shortening and abnormalities. The yearly incidence of femur shaft fractures ranges from 10 to 37 per 100,000 individuals, peaking in young males at age 27 and older women at age 80 [2].

The AO-Müller/Orthopaedic Trauma Association (AO/OTA) system is widely used to classify femur shaft fractures. It encompasses the classification of diaphyseal femur shafts as well as all long bone fractures. The fracture patterns are primarily classified into three categories: simple, wedge, and complex fractures[3]. When it comes to treating femur shaft fractures, intramedullary nailing (IMN) is the preferred method due to its low complication rates (4.9%) and high union rates (72% to 100%) for aseptic non-unions of noncomminuted femoral shaft fractures[4],[5].Nevertheless, because of the need for repeated surgeries, extended hospital stays, and the incapacity to resume regular activities, non-union continues to provide difficulties for orthopaedic surgeons as well as significant economical difficulties for patients. Non-union of femur shaft fracture has been linked to several risk factors, including open fractures, smoking, delayed weight bearing, comminution of the fracture site, instability of fracture reduction, nonsteroidal anti-

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inflammatory drugs that may interfere with fracture healing, and inadequate nail diameter selection [6]. According to Weresh et al., the nail locking technique and age were found to be highly correlated with the likelihood of healing[7]. Because this will result in favourable clinical results and an early return to work, it is imperative to comprehend fracture union in middle-aged patients.

When evaluating patients for studies or treatments involving femur fracture non-union, particularly in geriatric patients, it is important to establish clear inclusion and exclusion criteria to ensure the population is suitable for the objectives of the study or treatment. Inclusion criteria have certain characteristics such as age, fracture diagnosis, surgical history, osteoporosis, rotational instability, consent, and compliance [8]. Similarly, exclusion criteria have certain characteristics that would disqualify the patient from treatment protocol. It includes active infection, pathologic fractures, severe comorbidities, and past treatment for non-union fracture.

Minimally invasive surgical techniques offer several advantages, particularly for elderly patients with femur fractures. However, to achieve successful union, addressing the factors contributing to non-union, such as deforming muscle forces, osteoporosis, comorbidities, mobilization status, and nutrition, is vital. A holistic, multidisciplinary approach is necessary to overcome these challenges and promote optimal outcomes for geriatric patients.

II. CASE DESCRIPTION

A. Case 1

The case report describes a 72-year-old female presented with right hip pain and antalgic gait using a walker for ambulation. The patient also having comorbidities such as Diabetes mellitus (DM), Hypertension (HTN) and ischemic heart disease (IHD). Here is an in-depth detail based on the assessment, clinical findings, and imaging studies.

The patient had a medical history of proximal femur fracture sustained about 8 months ago by treated with a Proximal Femoral Nail (PFN) in a local hospital. Persistent pain, abnormal gait, and delayed or absent healing on X-rays are common indicators of a non-union. There may be underlying rotational instability or malalignment due to inadequate fixation or biological healing failure. Clinical examination and radiographic imaging (X-ray or CT scan) confirmed non-union and mal alignment.

Fig 1: X-Ray Showing the Pelvic and Femur Regions with PFN Implant

The management of patient by optimizing healing can be done through glycemic control and careful evaluation by a cardiologist to ensure the patient is fit for any further surgical intervention. Since the patient is struggling from non-union is confirmed then potential replacement of failed PFN by revision surgery and a combination of a Proximal Femoral Nail (PFN) with an additional plate of 35mm locking compression plate (LCP) is considered to enhance fixation and address rotational or axial instability. In addition, bone graft is done to stimulate the biological healing for bone loss or non-union.

Post operation monitoring of fracture through radiology is conducted on 6 weeks and after 12 months to evaluate the intensity healing and callus formation. The pharmacological support can be given to the patient based on their age and bone density Bisphosphonates or Denosumab along with calcium and vitamin D supplemented to support bone health or treat osteoporosis.

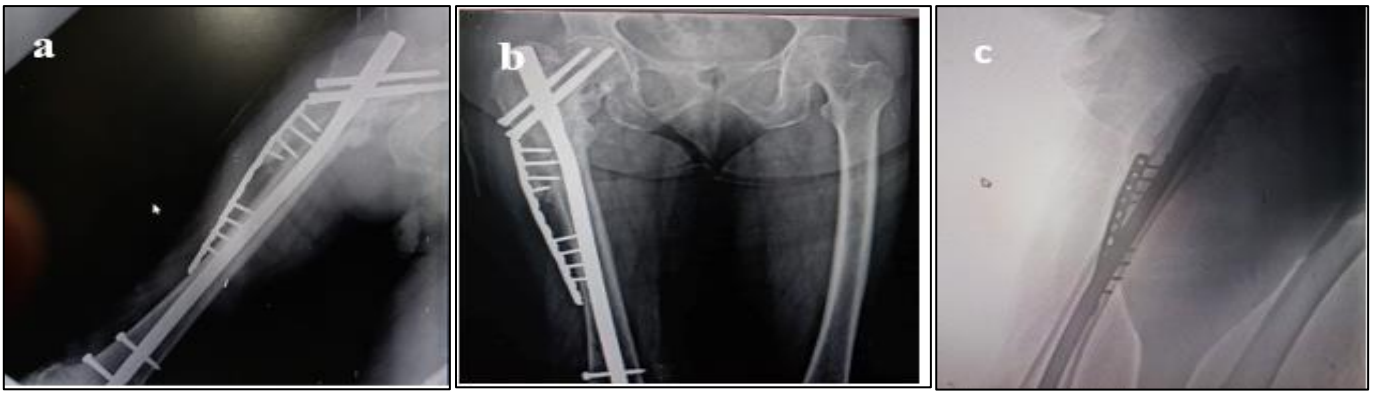

Fig 2: X Ray Images Showing the Follow Up after Surgery at 6 Weeks (a) and 12 Months(b), (c)

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Post-operative early mobilization and physiotherapy will be key to regaining mobility and preventing complications such as further muscle atrophy or joint stiffness. Regular monitoring of fracture healing via X-rays and close attention to blood sugar levels, cardiovascular status, and physical function.

B. Case 2

This case report describes 67-year-old male who was treated for an upper-third femur shaft fracture and lost follow-up for about 9 months after surgery due to the COVID-19 pandemic. The patient presented with complaints of pain in the right hip and limb shortening. The patient has hypertension (HTN) and is an alcoholic, both of which are important factors to manage the current condition. Here is an outline of the key concerns and potential next steps based on the provided details:

The possibility of non-union can be resulted from delayed follow up which leads to limb shortening and pain. Other potential complications due to delayed follow up are hardware failure and avascular necrosis. Although the X-ray shows the internal fixation hardware (an intramedullary nail and screws), the pain and limb shortening could suggest possible failure of the hardware. Over time, stress on the hardware could lead to issues, especially if the fracture did not heal correctly. Whereas pain in the hip after a long period of immobility could also point to avascular necrosis, a condition where blood flow to the femoral head is compromised, leading to bone death. This is more common in older individuals and those with a history of alcohol abuse.

Fig 3: X Ray Image Showing Post Surgery of Femur Shaft Fracture

Fig 4: Radiological Examination after 9 Months of Surgery Indicating Implant Failure

Further investigation through X-rays confirmed the non-union femur shaft fracture and the patient was planned to remove the implant and managed with combination of long PFN with locking compression plate of 3.5mm plates along with bone graft to stabilize the bone and regenerate fracture site to heal effectively. After augmentation of LCP with PFN, the patient underwent follow up at 6weeks, 6 months showed intact implants and signs of fracture healing. Final follow-up at 12 months yielded excellent range of motion in operated limb.to evaluate the healing and callus formation.

Fig 5: X Ray Image Showing Replacement with Long PFN with 3.5mm LCP

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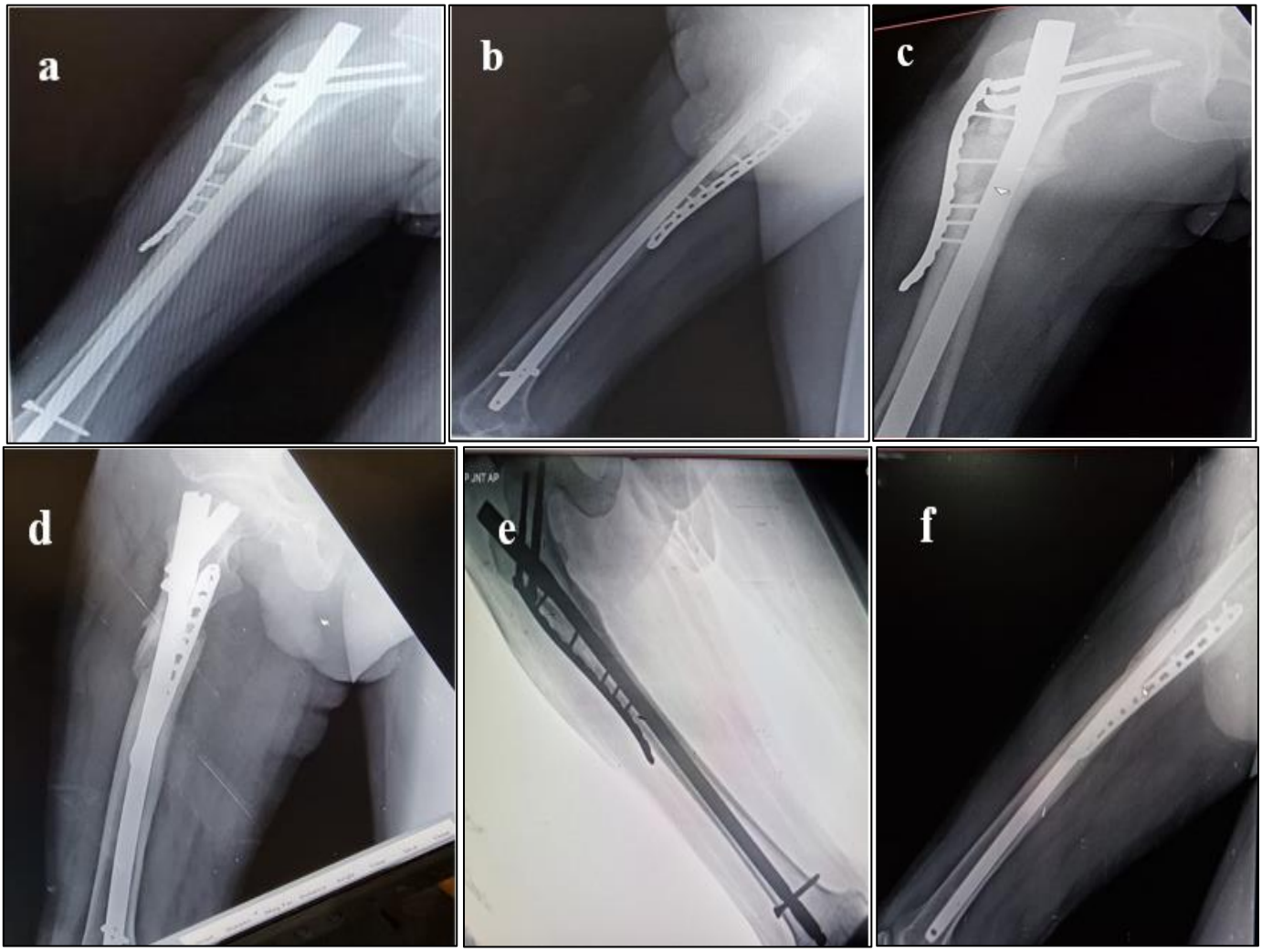

Fig 6: Post Operative Follow Up at 6 Weeks (a,b), 6 Months(c,d) and One Year(e,f)

If avascular necrosis is present, additional interventions such as core decompression or even hip replacement surgery may be necessary. A structured rehabilitation plan to help regain mobility and strength, with focus on managing limb length discrepancy. Optimization of blood pressure control and addressing alcohol dependence are essential for improving surgical outcomes and overall health. Limb shortening after a femur fracture can be addressed in several ways, if shortening is significant and causing functional issues, limb-lengthening procedures can be considered by surgical correction. Orthotic Devices such as custom shoe inserts or orthotics can help balance the leg length discrepancy for smaller differences.

C. Case 3

This case report describes a 67-year-old female patient with a right lower third spiral femur shaft fracture, who underwent closed reduction and internal fixation (CRIF) with a long proximal femoral nail (PFN) in January 2022. The patient has comorbidities, including diabetes mellitus (DM), hypertension (HTN), and chronic kidney disease (CKD), which are important factors to consider in her management and recovery.

The medical examination of the patient indicates spiral femur shaft fracture occurs due to a twisting force, often causing a helical or coiled pattern along the length of the bone. This type of fracture typically requires rigid internal fixation to maintain alignment during healing. The long PFN used in the surgical repair is a common choice for these types of fractures, offering good biomechanical stability and facilitating early mobilization.

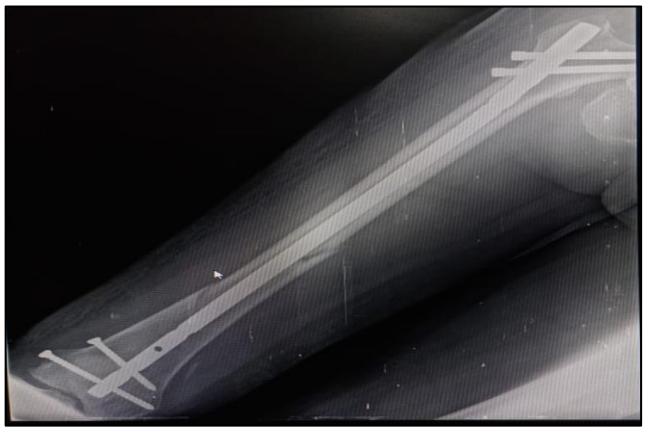
Fig 7: Radiograph Shows the CRIF with PFN in Jan 2022

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The regular monitoring through X-rays provided the healing progress of the fracture and showed signs of non-union and required re-evaluation of the treatment strategy. Physical examination also helped to assess for signs of hardware loosening (pain, instability) or complications like deep vein thrombosis (DVT) or infection. The patient decides to remove the implant as well as fibrous tissues thereby enhance the freshening of bone margin. The fracture site is augmented with locking compression plate of 3.5mm plates along with bone graft to stabilize the lower femur region and regenerate fracture site to heal effectively.

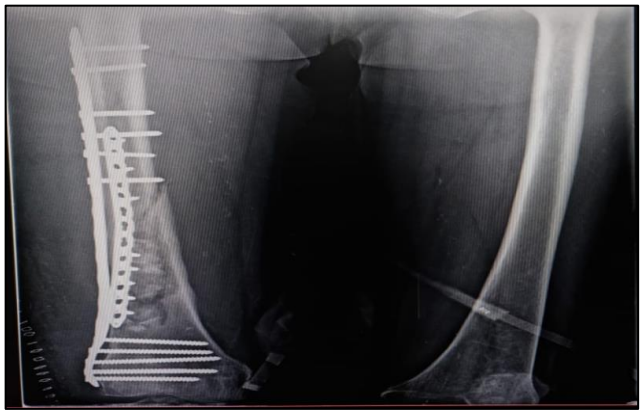

Fig 8: Post Operative X Ray Image Showing Implantation of LCP with Bone Graft

The post operative radiological examination of patient was followed at 6 weeks and 12 month to evaluate the healing reported the intact implant and ideal sign for callus formation.

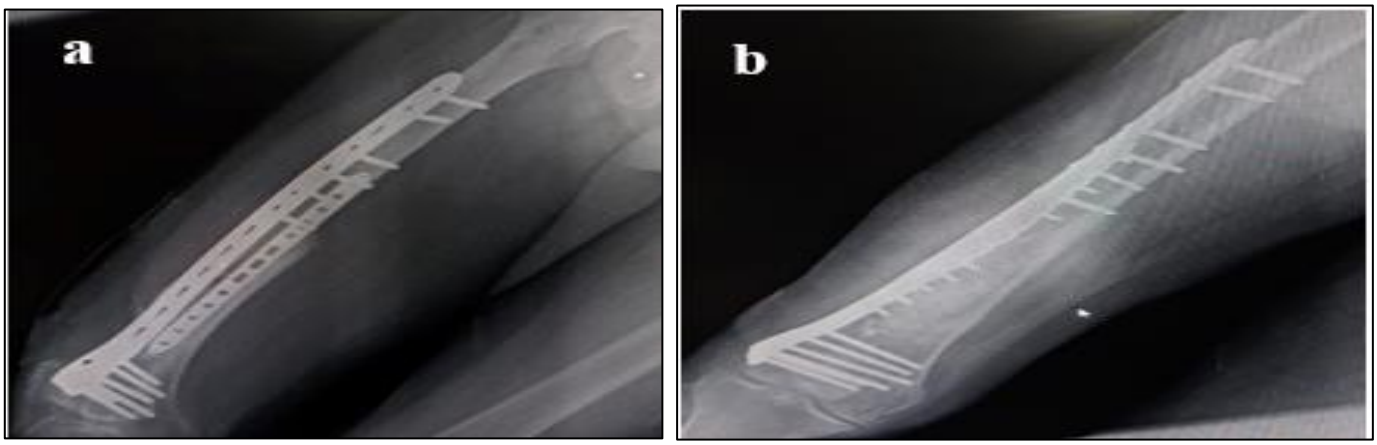

Fig 9: Post Operative Follow Up at Sixth Week (a) and 12 Months(b)

Spiral fractures can sometimes heal slowly, especially in patients with comorbidities like diabetes and CKD. Since the patient is having diabetes, will face higher risk for postoperative infections. Regular examination of signs of deep or superficial infections (fever, wound drainage, localized pain/swelling) were necessary. Customized physiotherapy to strengthen the quadriceps, hamstrings, and hip abductors, focusing on improving the range of motion, muscle strength, and gait pattern. As the patient is older and likely at risk of falls due to reduced mobility and underlying conditions, fall prevention strategies such as home safety assessments and assistive devices (e.g., walkers) should be considered.

D. Case 4

A 65-year-old female presented with pain at the fracture site and an antalgic gait with a history of distal femur shaft fracture in the lower third, which operated with closed reduction and internal fixation (CRIF) using an antegrade nail 8 months back. The patient also has known comorbidities, including diabetes mellitus (DM), hypertension (HTN), and osteoarthritis (OA) of the knee.

The patient persist pain after 8 months suggests potential complications such as non-union, delayed union, malunion, or hardware failure. These are common issues in fractures, especially in the lower third of the femur, where healing can be slower due to decreased blood supply. Diabetes mellitus (DM) increases the risk of delayed or non-union due to impaired bone healing, poor vascularization, and a higher risk of infection. Hypertension (HTN) needs to be well-controlled perioperatively, especially if revision surgery is required. Osteoarthritis (OA) of the Knee could be contributing to the patient's antalgic gait and pain, complicating the assessment of whether the pain is from the fracture site, knee arthritis, or both.

On thorough radiographic evaluation discovered the current state of fracture, non-union and assessed the condition of hardware. Due to mechanical instability at the fracture site and persistent stress on an inadequately healing fracture results in screw loosening or nail migration. Concomitant knee osteoarthritis experienced by the patient due to the pain in knee joint and at the fracture site complicated gait and lead to difficulty in fully assessing the fracture-related pain.

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The patient was planned to remove antegrade nail and replaced by retrograde nailing approach where retrograde intramedullary nail is inserted from the knee into the femoral canal, providing better stabilization for lower third fractures. Locking Compression Plates (LCP) can offer angular stability and may be combined with bone grafting. If there is evidence of poor healing, autologous bone grafting or synthetic bone grafts may be used to stimulate bone healing.

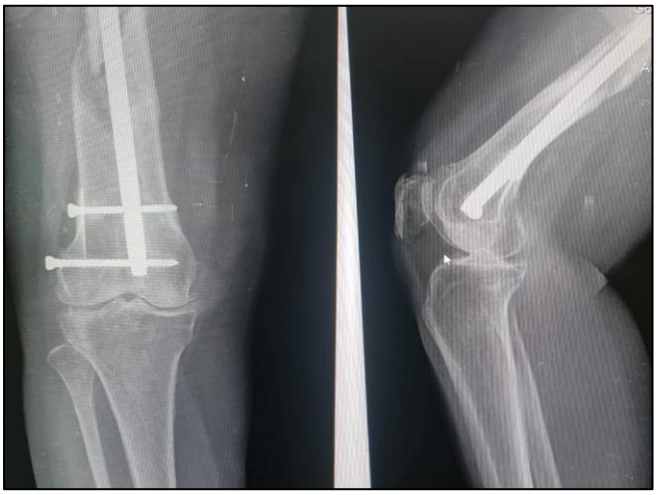

Fig 10: Preoperative X-Rays Showing CRIF using Antegrade Nail in Distal Femur Fracture Leads to Non-Union

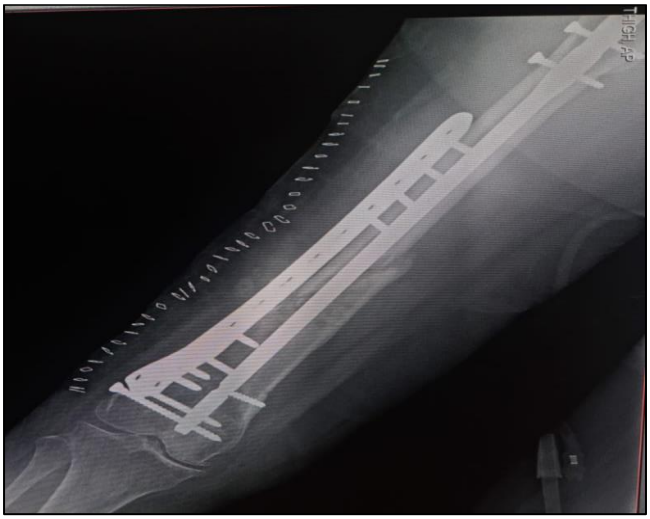

Fig 11: Post Operative X-Ray Showing Removal of Antegrade Nails by Retro Grade Intramedullary Nails and Augmentation Plating with LCP.

Postoperatively the patient was administered with Inj. teriparatide and calcium for three months daily to improve bone formation and healing. Focused rehabilitation exercises to improve strength and mobility of the quadriceps, hamstrings, and hip muscles. A structured program to improve her gait, address any compensatory movement patterns, and restore normal walking mechanics. Targeted physiotherapy interventions for pain relief, possibly in conjunction with medication, should be tailored to manage both the knee osteoarthritis and any pain related to the fracture site. Depending on the stability of the fracture, non-weight-bearing protocol initiated at 6 week of post operation. Partial or full weight bearing should do after the confirmed radiographic evidence of healing or after completed callus formation and it should be under supervision. Followed 1 year of post operation with the radiological examination which showed intact implants and signs of fracture healing.

Fig 12: Follow up after One Year Shows Healing Across the Fracture Line and Alignment

III. DISCUSSION

Over time, significant advancements have been made in the management of non-union femur fractures. Numerous methods have been reported for the treatment of these fractures. For the most part, these fractures were treated conservatively in the early 1900s. The concepts of the newly formed Arbeitsgemeinschaft fur Osteosynthesefragen (AO) were not used to treat these fractures until 1970 [9,10]. But these fractures still present a problem and are challenging to treat, even with the range of available treatment options. Although locking plates and retrograde intramedullary nails are the two most often used fixation techniques for fractured femurs, neither technique has been shown to be better than the other[11,12]. Jankowsky et al. found that there are similarities in the union rates of retrograde intramedullary nails and locking plates in their meta-analysis[13]. Surgeons needed a rigid construct for non-union management in cases of non-unions of the distal femur, which is why the more recent method of combining nail and plate was first described. In a clinical context, the use of an intramedullary nail to treat long bone non-union is not entirely novel. In a series of 38 femoral and tibial non-unions treated primarily with IM nails, Birjandinejad et al.'s 2009 study demonstrated the treatment's effectiveness. After adding a 4.5 mm compression plate construct with a nail in place, they found that 36 fractures, including all femoral fractures, healed in their series [14]. A retrospective study for non-union of the distal femur using a nail plate combination was carried out by Attum et al. [15]; they also concluded that all the patients in their study eventually underwent union. Quinzi and colleagues conducted a meta-analysis and found that while there were differences in the complication profiles, there were no statistically significant differences in the frequency of major

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complications or re-operations in fractures treated with locking plates, retrograde intramedullary nails, or distal femoral replacement[16]. Weight bearing was started in the post-operative period for all 15 patients, 6 of whom were native and 9 of whom were periprosthetic. Liporace and Yoon reported favorable short-term outcomes in all of their patients and discovered that none of them experienced hardware failures, non-union, or infections during the healing process [17]. By combining the advantages of plating and nailing, the technique confers increased biomechanical stability by shifting the weight-bearing axis more medially along the anatomic axis, increasing points of fixation, and creating a fixed-angle construct. This nail plate combination is crucial for early mobilization following fractures in the elderly, osteopenic, and/or obese. It aids in the patients' early rehabilitation, reducing the risk of pressure ulcers, DVT, and other injury-related complications. Additionally, they are crucial in inter- and peri-prosthetic fracture cases [18,19] as well as complex fractures involving significant communication or segmental defects [15].

In this study, we removed four non-union and fractured implants from patients using a combination of nail plates and bone grafts. All the patients made progress toward union, with good functional outcomes and a minimum 12-month follow-up. The negative impact of comorbidities of 4 patients may be reason for the development of non-union. Our surgical approach of removing the scar tissues and the insertion of an long PFN combined with 35mm LCP allowed for a more thorough and successful pursuit of post-operative rehabilitation. There was no loss of reduction visible on any of the follow-up radiographs. The patients were also able to begin partial weight bearing earlier due to effective healing. Our findings are like those of Attum et al.'s and Birjandinejad et al.[15,14]. It is uncertain whether the results of the nail plate construct are better or equivalent to dual plating in the non-union of distal femoral fractures because it is a relatively new procedure and there is not a comparative dual plating cohort in the study[20]. Because of the relatively short follow-up period (12–24 months), the main focus of our investigation was on clinico-radiological outcomes, which were measured by IKDC score and fracture union. The main limitations of our study are the small number of patients (4), and the relatively short follow-up period. However, more investigation and clinical trials are required to determine the wider applicability and long-term results of this surgical strategy. In these complex orthopedic settings, the value of tailored treatment, a multidisciplinary approach, and precise surgical technique cannot be emphasized enough to achieve positive outcomes.

IV. CONCLUSION

The study demonstrates that a combined approach using proximal femoral nails (PFN) and locking compression plates (LCP), augmented with bone grafts, offers a promising method for managing complex non-union fractures, especially in cases where previous implants have failed. The use of this combination provides increased mechanical stability, facilitating early mobilization and functional recovery. Radiographic evidence from follow-up visits showed excellent healing and bone union, highlighting the effectiveness of this method. While the results are positive, further investigation is necessary to confirm the long-term efficacy and broader applicability of this novel approach in orthopaedic surgery.

V. CLINICAL SIGNIFICANCE

This case report exemplifies the need for innovative and individualized approaches in the management of challenging non-union femur fractures. The use of a proximal femoral nail, intramedullary nail and locking plate (dual plating) with bone graft offers a potential solution, but the field requires more extensive research and clinical evidence to firmly establish the reliability and long-term outcomes of this approach. Despite the complexities involved, with careful planning, and a patient-centred approach, it is possible to achieve favorable results in addressing these intricate orthopaedic scenarios. Furthermore, the first treatment should be optimal to avoid revision.

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