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Original Research Article

Evaluation of the Functional Outcome of Open and Closed Reduction Techniques for Distal Femur Fractures: A Prospective Study

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Abstract:

Introduction: Distal femur fractures represent a prevalent occurrence frequently encountered by orthopedic surgeons in their routine clinical practice. The fractures in question present therapeutic challenges in terms of fracture treatment due to their typical compound nature, comminuted pattern, and susceptibility to deformation caused by muscle forces exerted on the distal fragment. Additionally, these fractures have a tendency to result in functional impairment of the knee joint due to the injury sustained by the quadriceps system. There exists a lack of a universally applicable implant for the treatment of distal femoral fractures. The implementation of the Distal Femur Locking Compression Plate (DF-LCP) represents a favorable development that has significantly revolutionized the treatment approach for these fractures. This is primarily attributed to its ability to conform to the anatomical shape of the distal femur, facilitated by the inclusion of combi-holes in the proximal configuration.

Objective: The aim of this study is to assess the functional outcome of both open and closed reduction techniques in the management of distal femur fractures.

Methods: The present study employed a rigorous methodology to investigate the research question at hand. This section will outline the materials and methods utilized in order to ensure the validity The present prospective study was conducted at the orthopedics department of a tertiary care teaching hospital located Cuttack, forone year. The study encompassed a cohort of 60 patients diagnosed with AO Type A and Type C distal femur fractures. The technique employed for stabilization involved closed or open reduction and internal fixation utilizing a DF-LCP. A comprehensive follow-up was conducted on all patients over a duration of 6 months, during which the functional outcome was evaluated using the standardised Knee Society Scoring System.

Results: Among the cohort of 60 patients, a noteworthy 63.33% (n=38) exhibited excellent outcomes, while 30% (n=18) demonstrated good outcomes. A smaller proportion of patients, approximately 6.66% (n=4), displayed fair outcomes, and a mere 3.33% (n=2) experienced poor outcomes.

Conclusion: The utilization of DF-LCP demonstrates notable efficacy and dependability as an implant for the management of distal femoral fractures classified as AO type A and type C while exhibiting a low incidence of complications. However, a meticulous comprehension of fundamental principles and discernment of the suitable fracture pattern is imperative in order to achieve a superior outcome.

Introduction

Distal femur fractures encompass fractures occurring within the distal 15 cm of the femur, specifically involving the distal femoral metaphysis (supracondylar) and articular surface (intercondylar). In the course of the progressive development of orthopedic surgery, the management of distal femur fractures has regrettably failed to attain clinical outcomes of a commensurate caliber when compared to other types of femoral fractures. The prevalence of distal femur fractures is estimated to be approximately 37 cases per 100,000 person-years [1].The management of distal femoral fractures in young adults poses a significant clinical challenge due to the typically high-energy nature of these injuries. In addition, these fractures often involve complex intra-articular fracture patterns and extensive comminution of the metaphysis. Over the past ten years, there has been a rise in the utilization of anatomic lateral locking plates in conjunction with biological fixation techniques as the preferred approach for managing these fractures. These treatment modalities have demonstrated promising biomechanical characteristics that enable them to effectively withstand varus collapse throughout an extended duration of postoperative monitoring [2-7].

The prevalence of open reduction and internal fixation has become increasingly apparent in recent years. The assortment of implants employed encompasses the AO blade plate, dynamic condylar screw, intramedullary interlocking supracondylar nails, and locking compression plates. Supracondylar fractures have a propensity to undergo varus collapse. During the implementation of an AO blade plate or dynamic condylar screw, it is common for the femoral shaft's shaft to be laterally pulled, resulting in the displacement of the weight-bearing line. This displacement occurs laterally, deviating from the anatomical axis of the femoral shaft [8]. One of the notable benefits associated with the utilization of an intramedullary device is its ability to effectively align the femoral shaft with the condyles, thereby mitigating the propensity for varus failure at the fracture site. Moreover, it is worth noting that the flexion motion of an intramedullary apparatus is significantly diminished, thereby resulting in a decreased likelihood of fixation failure in osteoporotic bone. Furthermore, the utilization of a retrograde intramedullary supracondylar nail offers notable benefits including the preservation of fracture hematoma, decreased blood loss, minimal soft tissue dissection, shorter operative time, reduced incidence of infection, and decreased duration of hospitalization. The initiation of early weight bearing is feasible due to the load-sharing characteristic exhibited by an intramedullary implant.

Surgical debridement, a procedure commonly employed in the medical field, has been observed to disrupt the intricate dynamics of fracture biology. This disruption may potentially hinder the application of minimally invasive osteosynthesis techniques [9]. Open fractures have been identified as an autonomous risk factor for non-union, implant failure, and deep infection in fractures of the distal femur [2,5,6,10].

Nevertheless, with the evolving nature of fractures requiring medical intervention, there has been a shift from uncomplicated fractures located outside the joint area, specifically supra-condylar fractures, to more intricate inter-condylar and metaphyseal comminuted fractures. Consequently, the suitability of these implants for such cases may be questionable. Double plating, as well as more recent advancements in locked plating techniques, have been recommended and endorsed in the medical field. Nevertheless, the utilization of double plating frequently leads to significant soft tissue stripping on bilateral aspects of the femur, thereby causing diminished blood supply and potential occurrences of non-union and implant failure [11-13].

The LCP, or Locking Compression Plate, is a construct consisting of a single beam. In this construct, the fixation strength is determined by the combined strength of all the interfaces between the screws and the bone. This is in contrast to unlocked plates, where the fixation strength relies solely on the axial stiffness or pullout resistance of a single screw. The distinctive biomechanical functionality of this device is predicated upon the principle of splinting, as opposed to compression. This approach facilitates flexible stabilization, thereby mitigating the occurrence of stress shielding while concurrently promoting the formation of callus. Moreover, when administered through a minimally invasive procedure, it facilitates expeditious wound healing, diminished incidence of infection, and decreased bone resorption due to the preservation of vascular perfusion [14].

The introduction of plates featuring the inclusion of locked screws has presented an opportunity to enhance the stability of fixation in cases involving osteoporotic bone or fractures located near or within the joint, where there is a limited epiphyseal segment [15]. The implant provides numerous points of fixed-angle contact between the plate and screws in the distal region of the femur, potentially mitigating the inclination for varus collapse commonly observed with conventional lateral plates[15].

Study objective

The objective of the current investigation was to evaluate the functional outcome of open and closed reduction for distal femur fractures.

Materials and Methods

The present prospective study was conducted within the orthopedics department of a tertiary care teaching hospital located in Cuttack. The study spanned for one year, ensuring a minimum follow-up period of 6 months. All patients underwent surgical intervention performed by an identical surgical team.

Inclusion Criteria

1. Adult patients presenting with AO type A and type C distal femur fractures, encompassing both closed and open fractures up to grade IIIA, are included in this study.
2. Patients who meet the criteria for surgical intervention and demonstrate a willingness to provide informed consent.

Exclusion Criteria

1. The patient presents with a type III B and C open distal femur fracture.
2. Individuals presenting with concomitant cranial, thoracic, visceral, and bodily injuries, as well as those exhibiting fractures in any location except for the distal femur within the same limb.

3. Pathological fractures refer to fractures that occur as a result of underlying pathological conditions affecting the integrity and strength of the bone. These fractures are distinct from traumatic
4. Patients presenting with nonunion, delayed union, and compartment syndrome are observed in the clinical setting.

This study encompassed a cohort of 60 patients diagnosed with distal femur fracture, who sought medical attention at the Orthopaedics emergencies and outdoor department. Upon admission, a comprehensive clinical evaluation was conducted for all patients, followed by the necessary interventions to achieve hemodynamic stability. A radiological assessment was performed to determine the nature of the fracture. This assessment included anteroposterior and lateral X-ray imaging of the femur, as well as a pelvic X-ray to exclude any proximal fractures. Additionally, a slab was applied above the knee for immobilization. A computed tomography (CT) scan was performed in accordance with the indicated clinical necessity.

The application of a splint to immobilize the fractured limb was undertaken as an initial intervention. Standard laboratory tests were performed, and the patient's suitability for anesthesia and surgery was determined. The patients underwent surgical procedures while under the administration of either spinal anesthesia or general anesthesia, following the acquisition of written informed consent. A tourniquet was appropriately applied at the location of the fracture site, as deemed suitable. In instances involving fractures of the 33A type, closed reduction was successfully accomplished through the utilization of diverse instruments such as clamps or ST pins, functioning as a joystick to manipulate the fracture fragments. Subsequently, fixation was performed using the minimally invasive plate osteosynthesis (MIPO) technique with the employment of a DF-LCP. In instances of fractures classified as 33C type, the initial course of action involves the implementation of closed reduction. If successful in achieving anatomical alignment, the fracture is subsequently stabilised using the minimally invasive percutaneous plate osteosynthesis (MIPO) technique. However, if closed reduction fails to achieve the desired anatomical reduction, an alternative surgical approach known as the swashbuckler's approach is employed to adequately expose the fracture fragments. Anatomical reduction of all intraarticular fragments has been performed. In instances of medial wall comminution, the medial aspect is additionally reinforced using plates and screws in order to mitigate the risk of Varus collapse. Following a comprehensive wound wash, the closure procedure is executed in a sequential manner, involving the application of multiple layers. Subsequently, an aseptic dressing is meticulously applied to the wound site. The utilization of the suction drain was observed in a subset of the cases.

Follow-up procedures and postoperative protocol

The postoperative protocol and subsequent follow-up procedures are essential components of the medical management plan. These measures are implemented to ensure optimal recovery and monitor the patient's progress after a surgical procedure

The removal of drains occurred within the postoperative period of 24 to 48 hours. The patient's treatment regimen included the administration of antibiotics and analgesics in accordance with their individual needs. The sutures were successfully extracted on the 12th to 14th day following the surgical procedure. Early mobilisation was initiated expeditiously, commencing on the initial post-operative day. The mobilisation of joints is typically achieved through the implementation of active or active-assisted movements. In instances involving articular fractures, the implementation of continuous passive motion has demonstrated potential efficacy in the restoration of joint motion. A series of follow-up assessments were conducted at specific intervals following the surgical procedure, including evaluations at 2 weeks, 6 weeks, 3 months, and ultimately at 6 months within the postoperative timeframe. During each subsequent visit, the radiological and functional evaluation was conducted utilizing the Knee Society Scoring System [16, 17]. The initiation of non-weight-bearing ambulation was promptly undertaken, with subsequent progression to partial weight-bearing in a gradual manner, upon the observation of radiological union on radiographic images. Following the completion of fracture consolidation, the patient was granted permission to engage in full weight-bearing activities.

Objectives of Rehabilitation

- A range of approximately 65°-70° flexion is deemed necessary during the swing phase of a typical gait pattern.
- Approximately 90 degrees of flexion is necessary for the purpose of ascending and descending stairs.
- Approximately 105 degrees of flexion is necessary to facilitate the prompt elevation from a seated position in a low chair, as well as to effectively perform the task of tying one's shoes.

In order to attain the desired outcome, continuous passive motion (CPM) therapy was prescribed on a daily basis for a duration of 2-3 weeks until the patient achieves a flexion angle exceeding 100 degrees.

Results

The present study aimed to investigate the efficacy of the Distal Femur Locking Compression Plate (DF-LCP) in the management of distal femur fractures. A total of 60 cases, including both closed and open fractures up to grade IIIA, were included in the study. The study cohort consisted of patients with ages ranging from 25 to 72 years, with a mean age of 45.9 years.

Table 1: Distribution of age in patients

Age (in years)	No. of patients	Percentage
20-40	28	46.66
41-60	20	33.33
61-80	12	20

In a cohort of 60 individuals, the prevalence of male cases was 40 (66.66%), while the remaining 20 cases (33.33%) were attributed to females. The observed male-to-female ratio in a cohort of 22 patients is 36.66%, with a higher representation of males on the left side. The predominance of right-sided involvement is likely attributed to the right side's dominance in the majority of individuals, as well as the fact that during road traffic accidents, the primary impact is often sustained by the more actively utilized limb.

Table 2: Distribution of sides in patients

Side	No. of patients	Percentage
Right	38	63.33
Left	22	36.66

Among a cohort of 60 patients, the prevalence of Muller type A1 fractures was observed in 18 individuals, accounting for 30% of the total sample. Additionally, 6 patients (10%) exhibited A3-type fractures, while 16 patients (26.66%) presented with C1 type fractures. Furthermore, 14 patients (23.33%) displayed C2 type fractures, and 6 patients (10%) were diagnosed with C3 type fractures. The observed correlation in our study may potentially be attributed to a higher level of male participation in outdoor activities, thereby resulting in increased susceptibility to high-energy trauma.

Table 3: Distribution of sex in patients

Sex	No of patients	Percentage
Male	40	66.66
Female	20	33.33

In the present investigation, the predominant modality of injury was identified as road traffic accidents (RTA), impacting a total of 40 individuals, accounting for 66.66% of the patient population. Subsequently, incidents involving falls within the home environment were observed in 14 patients, representing 23.33% of the cohort, while falls from stairs were documented in 6 patients, constituting 10% of the sample.

Table 4: Fracture classification in patients

Muller type	No. of patients	Percentage
A1	18	30
A3	6	10
C1	16	26.66
C2	14	23.33
C3	6	10

In the current investigation, a total of 60 patients were assessed, revealing that a mere 2 patients exhibited the occurrence of a complication, specifically a superficial infection. The patient, presenting with a superficial infection, exhibited a favourable response to treatment through the administration of oral antibiotics. Among a cohort of 60 patients, a total of 38 individuals were observed, resulting in a prevalence rate of 126.66%. Among a cohort of 30 patients, our investigation revealed varying durations for radiological union. The minimum time required for this process was observed to be 16 weeks, accounting for 20% of the total patient population. Subsequently, a majority of patients, comprising 43.33%, exhibited radiological union within the range of 18 to 20 weeks. A smaller subset of 4 patients (6.66%) necessitated 22 weeks for this union to occur. Notably, a significant proportion of 18 patients (30%) experienced a

radiological union that exceeded the 22-week threshold.

The present study comprised a total of 36 patients who successfully attained knee flexion exceeding 100 degrees. Additionally, 18 patients demonstrated knee flexion surpassing 80 degrees, while 6 patients exhibited knee flexion exceeding 60 degrees.

In our study, a total of 38 patients (63.33%) exhibited excellent outcomes based on the knee society score, while 16 patients (26.66%) demonstrated good outcomes. Additionally, 4 patients (6.66%) displayed fair outcomes, and 2 patients (3.33%) exhibited poor outcomes. These findings pertain specifically to patients who experienced afflictions on the right side.

Table 5: Injury mode in patients

Mode of injury	No. of patients	Percentage
RTA	40	66.66
Fall from stairs	6	10
Fall at home	14	23.33

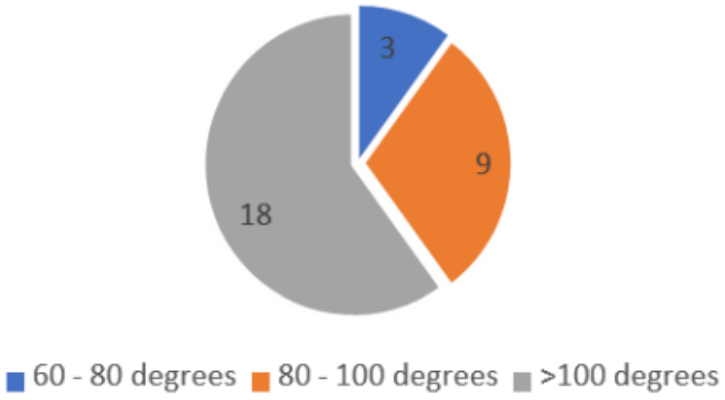

Figure 1: Knee flexion

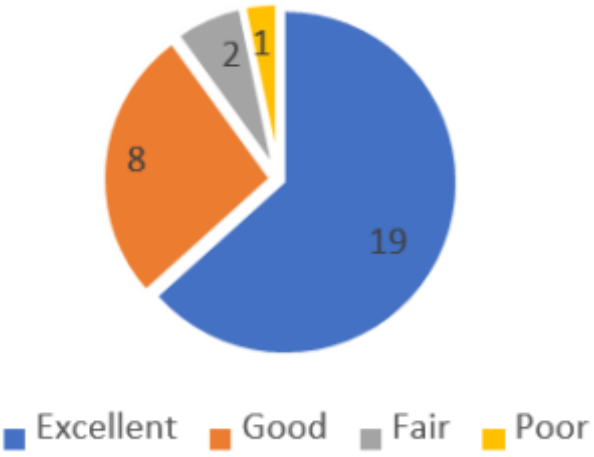

Figure 2: Outcome

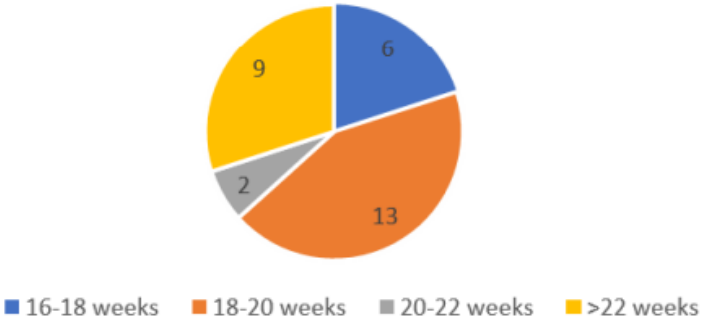

Figure 3: Radiological union

Discussion

Fractures of the distal femur in young adults are typically caused by high-energy trauma. These injuries place significant stress on the internal fixation construct, particularly when there is bone loss, which can occur over an extended period of follow-up [18]. The occurrence of fracture union and implant failure presents a dynamic interplay, particularly in the context of open fractures, where the biomechanical environment is inherently unfavorable. Lateral locking plates have emerged as the prevailing method of treatment for distal femoral fractures, exhibiting satisfactory rates of non-union as supported by various studies [19]. Both fixed-angle and variable-angle constructs have demonstrated favorable outcomes in both high-energy and low-energy fractures [20-22].

In a study conducted by JB Giles et al., a cohort of 26 patients presenting with supracondylar and intercondylar fractures were managed using a supracondylar plate and lag screw assembly technique [23]. The device demonstrated a high degree of efficacy in the restoration of the physiological alignment of the femur and the intra-articular anatomy of the knee joint, as per their report. In a previous study conducted in 1989, JM Siliski documented the utilization of the AO blade plate technique for the treatment of 52 cases involving supracondylar and intercondylar fractures [24].

The researchers adhered to the AO classification of fractures and employed the Neer rating system to assess the outcomes. The findings revealed a commendable 92% rate of excellent and good results in C1 type fractures, a satisfactory 72% rate of good/excellent results in C2 type fractures, and a notable 85% rate of good/excellent results in C3 type fractures. In the year 1995, a comparative study was undertaken by Krickler and Butt MS et al. to investigate 42 cases of displaced supracondylar and intercondylar fractures of the femur in elderly patients. A total of 20 patients underwent operative intervention utilizing the AO DCS and side plate assembly, while 22 patients were subjected to skeletal traction followed by cast bracing [25].

In a study conducted by Gellman RE et al. in 1996, a total of 26 cases of supracondylar femoral fractures were examined. The fractures were managed using an intramedullary supracondylar nail, resulting in 77% of cases achieving good to excellent outcomes. The average knee range of motion observed was 104 degrees [26].

In the year 2000, Kumar A et al. published a study presenting the outcomes of 18 distal femoral fractures in elderly patients. All fractures were classified as Type-A according to the AO classification system. The patients were treated using a retrograde titanium supracondylar nail. In the conducted study, a total of 15 fractures were observed, with a remarkable union rate of 93.7%. The average duration for these fractures to successfully unite was found to be 3.6 months. The mean degree of flexion achieved at the knee joint was 100.6 degrees. No instances of implant failure were observed [27].

Dugan et al. underscored the significance of soft tissue sleeve maturation in order to enhance the assimilation of cancellous bone grafts in cases of open distal femur fractures. The average duration until secondary bone grafting was observed to be 3.6 months (with a range of 1 to 6 months) in their study [28].The majority of fixation constructs employed for distal femoral fractures involve the utilization of lengthy lateral plates in order to enhance stress distribution. However, it is worth noting that the revision of such constructs can pose significant challenges [29].The utilisation of antibiotic spacers is increasingly gaining popularity in the medical field. In conjunction with this, the timely implementation of bone grafting using the Masquelet technique has proven to be effective in facilitating bone union. This proactive approach seamlessly integrates these two methods for optimal patient outcomes [30].

The present study demonstrates that the fixation of distal femur fracture utilising a locking compression plate (DF-LCP) yielded exceptional functional outcomes, characterised by prompt union, favourable range of motion in the knee joint, early initiation of weight-bearing activities, and resumption of normal daily activities. Notably, no significant complications were encountered throughout the course of treatment.

Conclusion

With the advancement of locking compression plating in the treatment of distal femoral fractures, particularly those that are comminuted and involve the joint, several previous limitations have been effectively addressed. These improvements include enhanced stability achieved through the implementation of locking compression plating principles, the availability of multiple screw options in the distal fragment to facilitate the fixation of multiple fragments and restore anatomical congruity, and the provision of stable fixation between the distal and proximal fragments.

Consequently, these advancements result in increased stability, enabling early mobilization of the affected limb. The utilization of Dynamic Fixation with a Distal Femoral Locking Compression Plate (DF-LCP) has been observed to exhibit efficacy in cases involving osteoporotic bones. This technique has been associated with several advantages, including shorter operative duration, accelerated recovery, early mobilization leading to a reduced period of hospitalization,

enhanced union rate, and excellent functional outcome. Furthermore, the incidence of complications is minimal. However, a meticulous comprehension of fundamental principles and accurate identification of the suitable fracture pattern is imperative in order to achieve optimal outcomes.

References

1. Arneson TJ, Melton LJ3rd, Lewallen DG et al. Epidemiology of diaphyseal and distal femoral fractures in Rochester, Minnesota, 1965-1984. Clin orthop. 1988;234:188-94.
2. Wenger D, Andersson S. Low risk of nonunion with lateral locked plating of distal femoral fractures-a retrospective study of 191 consecutive patients. Injury. 2018.
3. Poole WEC, Wilson DGG, Guthrie HC et al. 'Modern' distal femoral locking plates allow safe, early weight-bearing with a high rate of union and low rate of failure. Bone Joint J. 2017; 99:B:951–B:957.
4. Singh A, Rastogi A, Singh V. Biomechanical comparison of dynamic condylar screw and locking compression plate fixation in unstable distal femoral fractures: an in vitro study. Indian J Orthop. 2013;47:615–620.
5. Ricci WM, Streubel PN, Morshed S et al. Risk factors for failure of locked plate fixation of distal femur fractures: an analysis of 335 cases. J Orthop Trauma. 2014; 28:83–89.
6. Hoffmann MF, Jones CB, Sietsema DL et al. Clinical outcomes of locked plating of distal femoral fractures in a retrospective cohort. J Orthop Surg Res. 2013; 8:43.
7. Henderson CE, Kuhl LL, Fitzpatrick DC, Marsh JL. Locking plates for distal femur fractures: is there a problem with fracture healing? J Orthop Trauma. 2011; 25:S8–S14.
8. Nirav BR, Rajesh AS, Harshad K, Patel A, Punit JT. Study of Retrograde Intramedullary Nailing In Distal One Third femur fracture. IOSR-JDMS. 2016; 15(4):18-23.
9. Schatzker J (1998) Fractures of the distal femur revisited. ClinOrthop Relat Res. 1998:43–56.
10. Rodriguez EK, Boulton C, Weaver MJ et al. Predictive factors of distal femoral fracture nonunion after lateral locked plating: a retrospective multicenter case-control study of 283 fractures. Injury. 2014; 45:554–559.
11. Michael Z, Mohit B et al. Operative treatment of acute distal femur fractures: systematic review of 2 comparative studies and 45 case series (1989-2005). J Orthop Trauma. 2006; 20:366-71.
12. Kregor PJ, Stannard J, Zlowodzki M et al. Distal femoral fracture fixation utilizing the Less Invasive Stabilization System (L.I.S.S.): the technique and early results. Injury. 2001;32(3):SC32-47.
13. Schutz M, Muller M, Regazzoni P et al. Use of the Less Invasive Stabilization System (LISS) in patients with distal femoral (AO33) fractures: a prospective multicenter study. Arch Orthop Trauma Surg. 2005;125(2):102-8.
14. Kregor PJ, Stannard JA, Zlowodzki M et al. Treatment of Distal Femur Fractures Using the Less Invasive Stabilization System: Surgical Experience and Early Clinical Results in 103 fractures. J Orthop Trauma. 2004;18(8):509-20.
15. Heather V, Theresa H, John S et al. Failure of LCP condylar plate fixation in the distal part of the femur. J Bone Joint Surg. 2006;88-A:846-53.
16. KILIÇOGLU ÖI,ea. "Comparison of locked plating and intramedullary nailing for periprosthetic supracondylar femur fractures after knee arthroplasty." Acta orthopaedica Belgica. 2013;79(4):417-421.
17. Fankhauser Fea. "Minimal-invasive treatment of distal femoral fractures with the LISS (Less Invasive Stabilization System) A prospective study of 30 fractures with a follow-up of 20 months." Acta Orthopaedica. 2004;75(1):56-60.
18. Elsoe R, Ceccotti AA, Larsen P. Population-based epidemiology and incidence of distal femur fractures. Int Orthop. 2018; 42:191–196.
19. Koso RE, Terhoeve C, Steen RG, Zura R. Healing, nonunion and re-operation after internal fixation of diaphyseal and distal femoral fractures: a systematic review and meta-analysis. Int Orthop. 2018; 42:2675–2683
20. Kanakaris NK, Obakponovwe O, Krkovic M et al. Fixation of periprosthetic or osteoporotic distal femoral fractures with locking plates: a pilot randomised controlled trial. Int Orthop. 2018.
21. Dang KH, Armstrong CA, Karia RA, Zelle BA. Outcomes of distal femur fractures treated with the Synthes 4.5 mm VA-LCP curved condylar plate. Int Orthop. 2018.
22. Kim S-M, Yeom J-W, Song HK et al. Lateral locked plating for distal femur fractures by low-energy trauma: what makes a difference in healing? Int Orthop. 2018;42:2907–2914.
23. Giles JB, Delee JC, Heckman JD. Supracondylar Intercondylar fractures of femur treated by supracondylar plate and lag screw J bone Joint Surg Am. 1982; 64(6):864-70.
24. Siliski JM, Mahring M, Hopir P. Supracondylar and intercondylar fractures of femur treated by internal fixation JBJS. 1989; 70(1):95-104.
25. Butt MS Krikler SJ, Nafie S, Ali MS. Comparison of dynamic hip screw and gamma nail a prospective, randomized controlled trial. Injury. 1995; 26(9):615-18.
26. Gellman RE, Guy Paiement D, Hellary Green D. Treatment of supracondylar femoral fractures with a retrograde intramedullary nail. CORR. 1996; 332:90-97.

27. Kumar A, Jasani VM, Butt MS. Management of distal femoral fractures in elderly patients using retrograde titanium supracondylar nails. Injury. 2000; 31(3):169-175.
28. Dugan TR, Hubert MG, Siska PA et al. Open supracondylar femur fractures with bone loss in the polytraumatized patient -timing is everything! Injury. 2013; 44:1826–1831
29. Vallier HA, Hennessey TA, Sontich JK, Patterson BM. Failure of LCP condylar plate fixation in the distal part of the femur. A report of six cases. J Bone Joint Surg Am. 2006; 88:846–853
30. Masquelet AC, Begue T. The concept of induced membrane for reconstruction of long bone defects. Orthop Clin North Am. 2010; 41:27–37.