Annals of Clinical and Analytical Medicine
Original Research

Clinical results of closed intramedullary nailing in femoral diaphysis fractures

Bedrettin Akar[1], Mehmet Bülent Balioğlu[2]
[1] Department of Orthopedics and Traumatology, Sakarya Yenikent State Hospital, Sakarya
[2] Department of Orthopedics and Traumatology, Basaksehir Cam Sakura City Hospital, Istanbul, Turkey

Abstract

Aim: Although there are many methods in the surgical treatment of femoral diaphyseal fractures (FDF), the preferred methodnowadays is Anterograde closed intramedullary nail (AKIMN) application. While giving the clinical results of our operations and AIMN applications due to FDF, at the same time, in this study, we aimed to present the most accurate options to the orthopedic researchers who are looking for indications by mentioning other treatment methods.

Material and Methods: In our retrospective study, in 25 patients with a mean age of 33.5 years who were urgently admitted to the Istanbul Training Hospital Orthopedics and Traumatology clinic due to FSF between 1997 and 1999, different models (Orthofix, Russel Tailor, Ünku type 1) and different locking types (Static and Dynamic) of AIMN were applied. During the mean follow-up period of 24.5 months, radiological and clinical examinations of the patients were performed. Evaluation of the results was done according to Thoresen criteria [25].

Results: Seventeen patients came to control visits. Nonunion and malunion were not seen in those who came to the control. In clinical and functional examination, it was observed that hip and knee joint movements were comfortable and functional loss did not develop. According to Thoresen criteria, 14 patients were evaluated as very good, one patient was good due to pain in the tuberositas region, one patient was evaluated as moderate due to 5-degree valgus deformity, and one patient was evaluated as bad due to post-op infection.

Discussion: AIMN is the first preferred method in the treatment of femoral diaphysis fractures caused by high-energy traumas. Since the fracture line is not opened, the amount of bleeding and the risk of infection decrease, the mobilization start time is shortened, and union is accelerated.Static locking should be preferred in order to prevent shortening and rotation in segmental fractures. Reamerization of the medulla accelerates the union and shortens the healing process.

Keywords

Femoral Fractures, Intramedullary Nailing, Orthopedic Surgery, Secondary Injury, Osteosynthesis, Fracture

DOI: 10.4328/ACAM.21053 Received: 2022-01-11 Accepted: 2022-02-14 Published Online: 2022-02-19 Printed: 2022-03-01 Ann Clin Anal Med 2022;13(3):330-334
Corresponding Author: Bedrettin Akar, Yenidoğan Mahallesi, Arslanağzı Sokak, No: 4, Yenidoğan, İzmit, 41000, Kocaeli, Turkey.
E-mail: drbedrettin@gmail.com P: +90 532 208 96 52
Corresponding Author ORCID ID: https://orcid.org/0000-0001-7461-1777

Introduction

FDF occurs with high-energy traumas (traffic accident, falling from a height, gunshot wounds, etc.) and causes significant mortality and morbidity in patients. Although it can be seen at almost any age, it is especially common in young men [1,2,6,9]. FDF, which accounts for 8% of all fractures, was treated with conservative methods until the 20th century [4,5,7,15]. In these years, bed rest, plaster cast and traction were the treatment options.The first successful IMN application started in 1940 by Küntscher. A force of 280 newtonmeters is required to break an adult human femur, values above this value spread to the soft tissue.Winquist-Hansen classified femoral diaphysis fractures according to the degree of fragmentation. (Table 1) This classification is categorized as types 1,2,3 and 4 [3,9,18]. The currently accepted classification is the AO classification, and a coding system is used to define the type of fracture, resulting in 27 different models [24].

(3=femur, 2=diaphysis) Femur fracture has a high union potential and a low rate of pseudoarthrosis [3,8,11,13]. The aim of treatment is to achieve a quality union by providing the desired length and alignment with early mobilization[5,13,19]. In the early stages of fracture healing, although the intramedullary nail fills the canal completely, the periosteal circulation can still circulate the outer half of the cortex.The rapid union and remodeling of fractures after closed intramedullary nailing is due to excessive collateral circulation around the femoral diaphysis.If the medullary canal is wider in one fragment than the other, rotational forces control is weakened. In this case, locking screws are needed. These screws should be at least 2 cm away from the fracture line to ensure adequate stability [4,7,11,18].

Since static intramedullary nailing will delay the union of the fracture, it should be dynamized 8-12 weeks after the operation [3,8,14,22]. If dynamization is performed without adequate cortical stability and bone regeneration, it may result in shortening. It increases the stability of the fracture line by providing a wider contact surface between the bone and the nail. The entrance hole of the femoral nail should be from the anterior part of the piriform fossa just medial to the greater trochanter [5,9,16,24)]. The disadvantages of remerization include fat embolism and a temporary decrease in endosteal blood flow. However, until endosteal blood flow is restored, periosteal blood flow provides adequate support [2,21].

Material and Methods

AKIMN was applied to 25 patients who applied to Istanbul Training Hospital Orthopedics and Traumatology clinic between 1997-1999 due to FDF. The study was approved by the Ethics Committee of the institute of Health Sciences Sakarya University (E-71522473-050.0104-92635-548). Nail locking with different brands (Orthofix-Italy, Russel Tailor -USA, Ünku tip 1-Turkey) was applied to 17 patients who came to control (mean age of 33.5 (12 – 66) years, 16- males (64%), 9- females (36%). Static nail locking was applied to14 patients (56%), dynamic to 11 patients (44%).The mean follow-up period was 29.1 months (11 – 41).In addition to FDF, 7 patients had different types of fractures (fractures of the wrist, humerus, forearm, tibia, clavicle, etc.); 14 patients (56%) were left, 11 patients (44%) were right.Etiological reasons of fractures were traffic accidents in 13 patients (52%), 11 patients fell from a height (44%) and in 1 patient, due to dropping heavy weight.According to the AO classification, 18 patients had 32-A fractures and 7 patients had 32-B type fractures. The average time between admission to the hospital and the operation was 5 days (3-11) .

Skeletal traction was applied to the patients during the period from hospitalization to the day of operation. One patient was type 2 open fracture according to Gustilo-Anderson classification and prophylactic antibiotic treatment was applied. All of our patients were operated in the supine position on the traction table under the guidance of a scope. Orthofix type nails were applied in 19 of the patients (76%), Russell Taylor in 4 patients, Ünku in 1 patient, and rare nail from tuberculum adductorium in 1 patient.The average nail thickness used in the cases was 11.3 mm (10 mm-13 mm), and the average nail length was 39.4 cm (36 cm–42 cm).Quadriceps and hamstring exercises were started in patients in the early postoperative period. In the first 4-6 weeks, partial weight-bearing was performed with crutches until the radiological findings of union were obtained. Unsupported walking was allowed at 12 weeks. 1,3,6,12 of the patients.Radiological and clinical controls of the patients were performed at 1, 3, 6, and 12 months.

Results

Thoresen's classification table was used in the evaluation. In this table, fracture axis, ipsilateral knee motion arc, pain and presence of edema were divided into 4 categories. The patients were classified as excellent, good, moderate and poor (25). A patient with a good clinical outcome was transferred to a subgroup because of poor radiological evaluation. It was determined by clinical examinations that union and hip-knee functions were good in all those who came to the control. According to Thoresen criteria, 14 of our 17 patients (82.3%) were evaluated as very good, 1 patient was evaluated as good due to pain in the tuberositas region (5.8%), 1 patient was evaluated as moderate due to post-op valgus deformity (5.8%), 1 patient was evaluated as poor due to developing infection (5.8%) (Figure 2).

One patient presented with type 2 open fracture according to the Gustilo Andersen classification. Purulent discharge started to come from the incision in the 1st month after the intramedullary locking nail was applied to the patient. Selective antibiotic therapy was applied to the patient who was interned. In one patient, 20-degree valgus deformity developed on early post-op radiographs because the distal fragment could not

Table 1. Winquist and Hansen Classification of Femoral Fractures

Type	Description
I	Comminution is minimal or nonexistent at fracture site
II	Comminution involves a fragment larger than in type I but at least 50% of the circumference of the cortices of two major fracture fragments are intact
III	Between 50 and 100% of the circumference of two major fracture fragments is comminuted
IV	Cortical contact is lost; cortex is circumferentially comminuted over a segment of bone

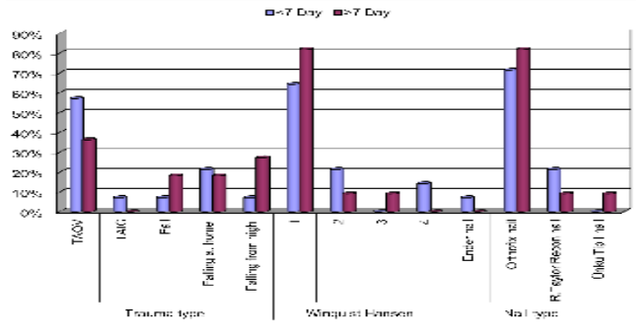

Figure 1. Comparison of patients with less than 7 days or more time between trauma and operation

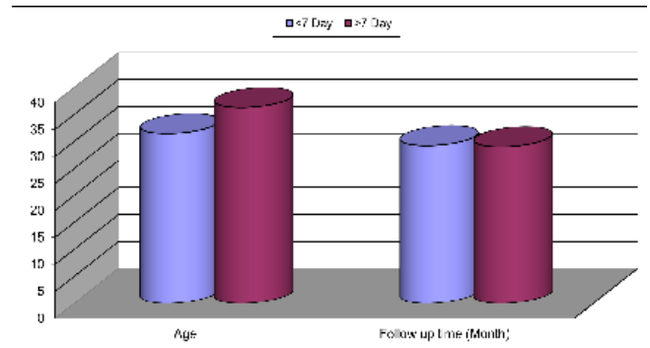

Figure 2. Comparison age and follow up time of patients with less than 7 days or more time between trauma and operation

Table 2. Statistical analysis

		Time between surgery and trauma (day)						P
		All patient group		≤7 Day		>7 Day		
Age		33,56±17,22		31,43±16,78		36,27±18,32		0,497*
Gender	Male	15	60,00%	10	71,43%	5	45,45%	0,188*
	Women	10	40,00%	4	28,57%	6	54,55%	
Side	Left	14	56,00%	7	50,00%	7	63,64%	0,495*
	Right	11	44,00%	7	50,00%	4	36,36%	
Trauma type	Traffic accident out of vehicle	12	48,00%	8	57,14%	4	36,36%	0,371*
	Traffic accident in car	1	4,00%	1	7,14%	0	0,00%	
	Fall	3	12,00%	1	7,14%	2	18,18%	
	Falling at home	1	4,00%	0	0,00%	1	9,09%	
	Falling at home	4	16,00%	3	21,43%	1	9,09%	
	Falling from high	4	16,00%	1	7,14%	3	27,27%	
Winquist Hansen	1	18	72,00%	9	64,29%	9	81,82%	0,297*
	2	4	16,00%	3	21,43%	1	9,09%	
	3	1	4,00%	0	0,00%	1	9,09%	
	4	2	8,00%	2	14,29%	0	0,00%	
Nail type	Ender nail	1	4,00%	1	7,14%	0	0,00%	0,435*
	Orthofix nail	19	76,00%	10	71,43%	9	81,82%	
	R.Taylor Recon nail	4	16,00%	3	21,43%	1	9,09%	
	Ünku Type I nail	1	4,00%	0	0,00%	1	9,09%	
Nail thickness	10	11	44,00%	5	35,71%	6	54,55%	0,693*
	11	8	32,00%	5	35,71%	3	27,27%	
	12	5	20,00%	3	21,43%	2	18,18%	
	30	1	4,00%	1	7,14%	0	0,00%	
Nail length	31	1	4,00%	1	7,14%	0	0,00%	0,336*
	32	1	4,00%	0	0,00%	1	9,09%	
	34	2	8,00%	2	14,29%	0	0,00%	
	36	7	28,00%	2	14,29%	5	45,45%	
	38	11	44,00%	7	50,00%	4	36,36%	
	40	2	8,00%	1	7,14%	1	9,09%	
	42	1	4,00%	1	7,14%	0	0,00%	
Post op complication	None	23	92,00%	14	100,00%	9	81,82%	0,096*
	Yes	2	8,00%	0	0,00%	2	18,18%	
Shortness	None	18	100,00%	9	100,00%	9	100,00%	-
Hip function	-	7	28,00%	5	35,71%	2	18,18%	0,359*
	Flex limited	1	4,00%	0	0,00%	1	9,09%	
	Full	16	64,00%	9	64,29%	7	63,64%	
	Hip limited	1	4,00%	0	0,00%	1	9,09%	
Knee function	Full	18	100,00%	9	100,00%	9	100,00%	-
Atrophy	None	17	94,44%	9	100,00%	8	88,89%	0,303*
	Yes	1	5,56%	0	0,00%	1	11,11%	
Fallow up time (month)		29,11±7,23		29,22±6,61		29,00±8,20		0,950*

* Independent t test + Chi-square test

be dominated during intramedullary nailing. Thereupon, the patient was revised 3 days later. In the long-term follow-ups of the patient, it was determined that the valgus deformity of 5 degrees remained, but in the clinical examination, the hip and knee movements were normal and the patient had no complaints. Skeletal traction was applied to the patients with a Kirschner wire passed through the tuberositas tibia before surgery. However, although one of our patients did not have any complaints due to the operation, it was observed that he had pain in the tuberositas tibia region that increased with walking (Figure 3). Fourteen patients who underwent static locking were dynamized at the end of 12-16 weeks, after the callus formation was sufficient in the radiological controls. In all patients, the femur was reamerized, and the thickest nail that could provide maximum contact between the nail and the medulla was preferred.

Discussion

While FDF is usually caused by high-energy traumas in young people, it can develop with low-energy traumas (falling at home, etc.) in the elderly population [1,2,8,22]. In AIMN application, the fracture union time is much shorter than open IMN, since the fracture line is not opened, the fracture hematoma is not evacuated and it is worked away from the fracture line. Generally, reference is made to the anterograde entrance to the pyriform fossa.There are also different references in the literature such as trochanteric and retrograde entry.In our study, we used anterograde piriform fossa entry [2,7,13,16].

Ayman El –Menyar et al. in their meta-analysis study, stated that there was no significant difference showing that early or late IM nailing accelerated union and healing in this type of fractures [3]. In our series, the average time between hospitalization and operation was 5 days.

Reamerization techniques of the medullary canal in FDF provide both mechanical and biological support to intramedullary nailing.Local formations accumulated in the fracture area by reamerization support the union by functioning like a bone graft containing osteoprogenitor cells and inductive molecules. While union is 98.5% in reamerized intramedullary nails (RIN), this rate is 84% in unreamerized nails (URIN).In their study, A-Bing Li et al. showed that RIN improves the union rate of fractures, shortens the union time, and reduces the incidence of nonunion or delayed union [6]. Reamerization may damage the blood flow of the inner cortical bone, but as a reaction, the periosteal blood flow may increase 6-fold, which can stimulate fracture healing; It has also been stated that RIN can provide greater stability and reduce the risk of implant replacement [7,11,17,23]. Clatworthy et al. concluded that fracture stability is an important determinant of rapid union [15]. A wider nail can be placed in the medullary canal after reamerization to improve cortical contact and provide greater stability. Farrar et al. reported that a tight-fitting nail increases the periosteal reaction [17]. Kanerva administered RIN to 42 patients and URIN to 39 patients in a series of 81 patients [4].

Bone union rate is much faster in the RIN group.The blood loss may be greater, but it will never be at the level that requires a blood transfusion [4]. Thorosen et al. applied RIN to 48 patients and said that the results were very good [25]. Kalenderer applied URIN to 77 patients and stated that the lack of stability in the URIN caused by insufficient bone-implant surface contact was eliminated by the use of locking nails . In our study, we applied RIN to all patients. In IMN application, it is clearly seen that the RIN technique has distinct advantages over the URIN technique in terms of both stability and joining time. Brumback and Virkus reported that IMN techniques may cause embolization by causing a slight decrease in endosteal blood flow and an increase in intramedullary pressure, but this effect is temporary; this complication is slightly more pronounced in URIN than in RIN [21]. Nader Helmy et al evaluated the functional results of FDF treated with anterograde IMN through piriform fossa entry using 2 different objective measurements (KinCom muscle test and Gait analysis) [16]. Isokinetic muscle testing and gait analysis were performed on the patients' hip abductor, hip extensors, and knee extensors using a KinCom muscle testing machine.As a result, he stated that AKIMN applications caused mild muscle weakness in the hip abductor and extensors, which returned to normal in the following periods, and did not cause any change in the gait model in the gait analysis [16]. The majority of the authors argue that static locking is appropriate in order to prevent shortening and rotation in FDF. In our study, we applied static locking to 14 patients and dynamic locking to 11 patients. Static locking is load-bearing, dominates shortening and rotation, but osteoporosis develops in the bone when the stress is reduced.

Jiang et al. stated that with static locking, the length and rotation of the fracture line are preserved while micro-movement is limited [13]. Many studies have been conducted in the literature on when dynamization will occur after static locking.In order to accelerate the union of the fracture in patients, dynamization should be started from 12 -16 weeks when sufficient callus formation is seen. Thorosen started dynamization on average after 10-12 weeks, Winquist after 12 weeks, Brumback after 14 -16 weeks, Durakbaş after 9 weeks. Since the load on the implant after dynamization will create stress on the bone, this situation stimulates callus formation and increases the hardness of the existing callus [1,2,5,12]. In our study, we applied dynamization starting from 12 weeks in cases where we used static locking.The results of fixation with IMN in adolescent with FDF are satisfactory.Rigid IMN can be used easily in adolescents aged 12 and over. In our series, we applied rigid IMN to 2 of our 3 patients under the age of 15 and flexible IMN to 1 of our patients.Complications such as shortening, rotation, and avascular necrosis were not observed in the patients [6,9,14,20].

Segmental diaphyseal fractures of the femur are problematic for both the surgeon and the patient.Finelli et al. operated 6 patients with segmental fractures with IMN and reported the mean time to union as 7.2 months [20]. Kosuke Hamahashi et al., in their study of 17 patients with segmental fractures who had undergone IMN, stated that the displacement of the segmental part significantly affected and delayed union, and they took the 10 mm displacement of the segmental part as a reference point [5]. The surgeon is likely to consider open reduction using a bone clamp or cerclage wire, as prevention of displacement of 10 mm or more is not possible with closed maneuvers. [4]In our study, we applied IMN to 1 patient with segmental fracture.

Complications such as shortness, rotation, and infection did not develop in the patient, and complete union was observed in the 5th month. It has been stated in the literature that the IMN technique can be used safely in open FDF. Gansslen et al. applied IMN to 56 patients who developed FDF as a result of gunshot injury, achieving complete union in 23 weeks and no infection was observed in the series [23]. In our study, 2 patients had type 2 open fractures, and one had post-op infection, which was treated with room-specific antibiotics.

Conclusion:

1. Anterograde closed IMN technique is the first preferred method in FDF.
2. In FDF with segmental fragments, static locking must be done in order to prevent shortening and rotation.
3. Reamerization of the femoral medulla accelerates the union.
4. Patients should be mobilized on the 1st post op day, and hip and knee joint movements should be started early.

Scientific Responsibility Statement

The authors declare that they are responsible for the article's scientific content including study design, data collection, analysis and interpretation, writing, some of the main line, or all of the preparation and scientific review of the contents and approval of the final version of the article.

Animal and human rights statement

All procedures performed in this study were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards. No animal or human studies were carried out by the authors for this article.

Funding: *None*

Conflict of interest

None of the authors received any type of financial support that could be considered potential conflict of interest regarding the manuscript or its submission.

References

1. Angadi DS, Stepherd D.E.T, Vadivelu R. Rigid intramedullary nail fixation of femoral fracturesin adolescents: what evidence in is available? J Orthopaed Traumatol. 2014; 15:147-53.

2. Gabarre S, Alberada J, Gracia L, Puertolas S, Ibarz E, Herrera A. Influenza of gap size,screw configuration,and nail materials in the stability of anterograde reamed intramedullary nail in femoral transverse fractures. Injury.2017;48 (Suppl. 6): S 40-6.

3- El-Menyar, A., Muneer, M., Samson, D., Al-Thani, H., Alobaidi, A., Mussleman, P, et al. Early versus late intramedullary nailing for traumatic femur fracture management: meta-analysis. Journal of Orthopaedic Surgery and Research,2018 Jun 28. 13(1): 160

4. Kanerva, M., Pärnänen, T., Jokinen, J., Haaja, J., Ritvanen, A., & Schlenzka, D. Multi-axis fatigue experimentation system of intramedullary implants for femur and tibia. Journal of Orthopaedic Research. J.Orthop.Res.2020May;38(5):984-995

5. Hamahashi K, Uchiyama Y, Kobayashi Y, Ebihara G, Ukai T, Watanabe M. Clinical outcomes of intramedullary nailing of femoral shaft fractures with third fragments: a retrospective analysis of risk factors for delayed union. Trauma Surg Acute Care Open. 2019;4 (1):e-000203.

6. Li AB, Zhang WJ, Guo WJ, Wang XH, Jin HM, Zhao YM. Reamed versus unreamed intramedullary nailing forthe treatment of femoral fractures: A meta- analysis of prospective randomized controlled trials. Medicine (Baltimore).2016; 95(29):e42-48.

7. Ghouri, S. I., Alhammoud, A., & Alkhayarin, M. M. (2020). Does Open Reduction in Intramedullary Nailing of Femur Shaft Fractures Adversely Affect the Outcome? A Retrospective Study. Advances in Orthopedics, 2020, 1–5.

8. Song, S.-H. (2019). Radiologic Outcomes of Intramedullary Nailing in Infraisthmal Femur-Shaft Fracture with or without Poller Screws. BioMed Research International, 2019, 1–4.

9. Ricci WM, Gallagher B, Haidukewych GJ.Intramedullary nailing of femoral shaft fractures: Current Concept. J Am AcadOrthop Surg. 2009;17(5):296-305

10. Summers, S., & Krkovic, M. Bone transport with magnetic intramedullary nails in long bone defects. European Journal of Orthopaedic Surgery & Traumatology, 2020; 31(6), 1243–1252.

11. Wu, K.-J., Li, S.-H., Yeh, K.-T., Chen, I.-H., Lee, R.-P., Yu, T.-C.,Wu, W.-T. The risk factors of nonunion after intramedullary nailing fixation of femur shaft fracture in middle agepatients. Medicine,2019.98(29),e16559.

12. Rosemberg, D. L., Goiano, E. O., Akkari, M., & Santili, C. Effects of a telescopic intramedullary rod for treating patients with osteogenesis imperfecta of the femur. Journal of Children's Orthopaedics,2018. 12(1), 97–103.

13. Jiang M, Li C, Yi C, Tang S. Early intramedullary nailing of femoral shaft fracture on outcomes in patients with severe chest injury. A meta analysis. Sci Rep. 2016; 6:30566.

14. BaixauliSr F, Baixauli EJ, Sánchez-Alepuz E, Baixauli F Jr ''Interlocked intramedullary nailing for treatment of open femoral shaft fractures. Clin Orthop Relat Res. 1998;(350):67-73.

15. Clatworthy MG, Clark DI, Gray DH, Hardy AE. Reamed versus unreamed femoral nails. A randomised prospective trial. J Bone Joint Surg Br. 1998;80(3):485-9.

16. Helmy N, Jando VT, Lu T, Chan H, O'Brien PJ. Muscle function and functional outcome following standard anterograde reamed intramedullary nailing of isolated femoral shaft fractures. J-Orthop-Trauma.2008;22(1):10-5.

17. Grundnes O, Reikerås O. Closed versus open medullary nailing of femoral fractures. Blood flow and healing studied in rats. Acta Orthop Scand. 1998;69 (2):177-80.

18. Kossmann T, Trentz O. Intramedullary nailing in closed femoral fractures. Ortopade. 1996;25(3):207-15.

19. Herrera A, Rosell J, Ibarz E, Albareda J, Gabarre S, Mateo J, et al. Biomechanical analysis of the stability of antergrade reamed intramedullary nails in femoral spiral fractures. Injury. 2020;51(Suppl1.):S74-9.

20. Finelli, C. A., dos Reis, F. B., Fernandes, H. A., Dell'Aquila, A., Carvalho, R., Miki, N., ... Salles, M. J. C. Intramedullary reaming modality for management of postoperative long bone infection: a prospective randomized controlled trial in 44 patients. Patient Safety in Surgery,2019;13(1).215-3

21. Brumback R J,Virkus W W. Intramedullary nailing of the femur: reamed versus nonreamed. J Am Acad Orthop Surg. 2000;8(2):83-90.

22. Deshmukh RG, Lou KK, Neo CB, Yew KS, Rozman I, George J. A technique to obtain correct rotational alignment during closed locked intramedullary nailing of the femur. Injury. 1998;29(3):207-10.

23. Gänsslen A, Gösling T, Hildebrand F, Pape HC, Oestern HJ. Femoral shaft fractures in adults: treatment options and controversies. Acta Chir Orthop Traumatol Cech. 2014;81(2):108-17.

24. Denisiuk M, Afşari A. Femoral Shaft Fractures. Treasure Island (FL): StatPearls Publishing;2020.

25. Thoresen BO, Alho A, Ekeland A, Strømsøe K, Follerås G, Haukebø A. Interlocking intramedullary nailing in femoral shaft fractures.Areport of forty-eight cases. J Bone Joint Surg Am.1985;67(9):1313-20

How to cite this article:

Bedrettin Akar, Mehmet Bülent Balioğlu. *Clinical results of closed intramedullary nailing in femoral diaphysis fractures. Ann Clin Anal Med 2022;13(3):330-334*