Annals of International Medical and Dental Research
E-ISSN: 2395-2822 | P-ISSN: 2395-2814
Vol-10, Issue-2 | March-April 2024
https://doi.org/10.53339/aimdr.2024.10.2.6
Page no- 48-57 | Section- Research Article (Orthopaedic Surgery)

Post-Operative Evaluation of Masquelet Technique for Treating Infected Non-Union of Femoral Shaft Fracture

S.M Faisal Haque[1*], Md. Wahidur Rahman[2], Subir Hossain[3], Md. Hamidul Islam[4], Ashiq Ahmed[5], Md. Zakaria Bin Hamid[6], Uday Kumar Sarker[7], Md Mostafizur Rahman[8]

[*1]Registrar, Department of Orthopaedic Surgery, National Institute of Traumatology & Orthopaedic Rehabilitation (NITOR), Dhaka, Bangladesh,
Email: faisal211bcs@gmail.com,
Orcid ID: 0009-0008-92615016
[2]Professor, Department of Orthopedic Surgery, National Institute of Traumatology & Orthopaedic Rehabilitation (NITOR), Dhaka, Bangladesh,
Email: aritta23@gmail.com,
Orcid ID: 0009-0002-6305-3284
[3]Assistant Professor, Department of Orthopedic Surgery, National Institute of Traumatology & Orthopaedic Rehabilitation (NITOR), Dhaka, Bangladesh,
Email: suvro27@gmail.com,
Orcid ID: 0000-0001-5593-2153
[4]Assistant Professor, Department of Orthopedic Surgery, National Institute of Traumatology & Orthopaedic Rehabilitation (NITOR), Dhaka, Bangladesh,
Email: drhamidul0@gmail.com,
Orcid ID: 0009-0000-8318-2599
[5]Assistant Registrar, Department of Orthopaedic Surgery, National Institute of Traumatology & Orthopaedic Rehabilitation (NITOR), Dhaka, Bangladesh,
Email: drahmedashiq@gmail.com,
Orcid ID: 0009-0002-7462-9488
[6]Medical Officer, Department of Orthopaedic Surgery, National Institute of Traumatology & Orthopaedic Rehabilitation (NITOR), Dhaka, Bangladesh,
Email: zakariabinhamid@gmail.com,
Orcid ID: 0009-0004-1682-7165
[7]Junior Consultant, Department of Orthopedics and Traumatology, M Abdur Rahim Medical College, Dinajpur, Bangladesh,
Email: udayshikhadghs29@gmail.com,
Orcid ID: 0009-0007-4402-0934
[8]Medical Officer, Department of Orthopaedic Surgery, National Institute of Traumatology & Orthopaedic Rehabilitation (NITOR), Dhaka, Bangladesh,
Email: mostafizurrahman48rmc@gmail.com,
Orcid ID: 0009-0003-1858-8623
*Corresponding author

Abstract

Background: Femoral shaft fracture, particularly those complicated by infected non-union, poses significant challenges in orthopedic surgery. This study aims to evaluate the effectiveness of the Masquelet Technique (MT) in treating such fractures, focusing on patient demographics, fracture characteristics, management strategies, and post-treatment outcome. **Material & Methods:** This prospective experimental study included 12 patients treated at the National Institute of Traumatology and Orthopaedic Rehabilitation, Dhaka, from May 2019 to August 2021. Participants predominantly comprised of young adults, with a male majority. The study assessed the type of fractures, fixation methods used (primarily the SIGN Nail), and the interval for applying the MT. Bone gap size, limb length discrepancy (LLD), complications, and bone and functional outcomes were meticulously recorded and analyzed. **Results:** In this study, 75% of the fractures were closed and predominantly resulted from road traffic accidents, which accounted for 83.33% of the cases. The most frequent bone gap range was 2.51-3.0 cm, observed in 41.67% of the participants, with an average gap size of 3 cm. Limb Length Discrepancy (LLD) ranging from 1 to 2.4 cm was experienced by 58.33% of the participants. While two-thirds (66.67%) of the participants did not develop any post-treatment complications, 33.33% experienced knee stiffness and 16.67% suffered from pin tract infections. A significant majority, 66.67%, achieved 'Excellent' outcomes in both bone union and functional recovery. **Conclusions:** The study demonstrates the effectiveness of the Masquelet Technique in managing femoral shaft fractures, particularly in achieving satisfactory bone and functional outcomes. Despite the challenges in managing large bone gaps and LLD, the technique showed promising results in terms of minimizing complications and enhancing recovery.

Annals of International Medical and Dental Research
E-ISSN: 2395-2822 | P-ISSN: 2395-2814
Vol-10, Issue-2 | March-April 2024
https://doi.org/10.53339/aimdr.2024.10.2.6
Page no- 48-57 | Section- Research Article (Orthopaedic Surgery)

Received: 08 Octoober 2023
Revised: 16 December 2023
Accepted: 07 January 2023
Published: 29 February 2024

Keywords:- Femoral Shaft Fractures, Masquelet Technique, Bone Gap, Limb Length Discrepancy.

INTRODUCTION

Femoral shaft fractures constitute a significant orthopedic challenge due to their high incidence and the complexity of their management. These fractures predominantly occur as a result of high-energy trauma, particularly in younger individuals involved in motor vehicle accidents, and are also prevalent in the elderly due to low-energy falls, often exacerbated by osteoporosis.[1,2,3,4] The treatment of femoral shaft fractures is further complicated by various factors including the patient's age, the location and complexity of the fracture, and the presence of concomitant injuries. The incidence of these fractures, along with their associated risk factors such as male sex, type C fracture of AO/OTA classification, and motor vehicle accidents, highlight the clinical significance and the challenges they present in treatment.[5] A particularly challenging scenario in the management of femoral shaft fractures is the occurrence of infected non-union. This condition, characterized by the failure of fracture healing over an expected period, compounded by infection, not only prolongs patient suffering but also significantly complicates the treatment approach, often necessitating multiple surgical interventions.[6,7] The prevalence of infected non-union in femoral shaft fractures, though variable, has a significant impact on patients, leading to prolonged disability, pain, and a substantial burden on healthcare resources.[8,9] The standard treatment modalities for femoral shaft fractures have evolved over time, with intramedullary nailing being the preferred method. However, these standard treatments have limitations, particularly in the context of infected non-union cases. Challenges in these scenarios include achieving stable fixation, managing bone defects, and effectively controlling infection, all of which are crucial for successful treatment outcomes.[10,11] These limitations necessitate the exploration of alternative treatment techniques, especially for complex cases. The Masquelet technique, an innovative approach developed to address the specific challenges of infected non-union, involves a two-stage procedure. The first stage induces a foreign body reaction to form a membrane around a cement spacer placed in the bone defect. The second stage involves the removal of the spacer and filling the defect with autologous bone graft.[12] The theoretical basis of the Masquelet technique lies in the biological activity of the induced membrane, which secretes growth factors conducive to bone healing. Existing literature on the Masquelet technique demonstrates its application and outcomes in various complex orthopedic scenarios. Studies have shown its effectiveness in managing large bone defects, controlling infection, and promoting bone union in cases of infected non-union of femoral shaft fractures.[13,14,15] There were some gap in this study like short time outcome was seen ,culture sensitivity was not included etc . These gaps underscore the need for further research,

Annals of International Medical and Dental Research
E-ISSN: 2395-2822 | P-ISSN: 2395-2814
Vol-10, Issue-2 | March-April 2024
https://doi.org/10.53339/aimdr.2024.10.2.6
Page no- 48-57 | Section- Research Article (Orthopaedic Surgery)

specifically observational studies, to evaluate the post-operative outcomes of the Masquelet technique in the treatment of infected non-union of femoral shaft fractures. Such studies are crucial to validate the effectiveness of the technique, understand its limitations, and refine its application in clinical practice. The objective of the present study is to observe and evaluate the outcomes of the Masquelet technique in the post-operative treatment of infected non-union of femoral shaft fractures. This study aims to provide a comprehensive assessment of the technique's effectiveness, focusing on outcomes such as bone union, infection control, and functional recovery. The potential impact of this study is substantial. By providing detailed insights into the outcomes of the Masquelet technique in a specific clinical context, this research could contribute to the improvement of treatment strategies for infected non-union of femoral shaft fracture. It could influence future clinical practices, offering an alternative to traditional methods and potentially enhancing patient outcomes in these complex cases.

MATERIAL AND METHODS

This study was designed as a prospective experimental investigation, conducted from May 2019 to August 2021 at the National Institute of Traumatology and Orthopaedic Rehabilitation (NITOR) in Dhaka. The research focused on patients presenting with infected non-union femoral shaft fractures, a condition characterized by significant treatment challenges in orthopedic surgery. The study's sample size comprised 12 patients, determined based on the reported incidence rate of femoral shaft fractures, which is 37.1 per 100,000 person-years as noted by Vicenti et al.[16] This incidence rate inherently led to a relatively small sample size, reflective of the condition's rarity. The selection of participants was conducted using purposive sampling, ensuring that each individual met the specific criteria set for this study. The inclusion criteria included patients with infected nonunion of the shaft of the femur, fractures of the shaft of the femur including 5cm distal to the lesser trochanter proximally and 5cm proximal to the epicondylar axis of the femur distally, and patients who were anesthetically fit with manageable comorbid conditions. The exclusion criteria included patients with pathological fractures (excluding chronic osteomyelitis), fractures involving the joints, and involvement of the metaphyseal or epiphyseal portion of the bone. Upon enrollment, a thorough evaluation of each patient was conducted. This evaluation included a detailed history, clinical examination, laboratory findings, and radiological assessments. Preoperative examinations focused on assessing the condition of the overlying skin, the stage of infection, limb length discrepancy (LLD), and the range of motion of the knee. Radiological evaluations were crucial in assessing the type of nonunion and any associated bone loss. Follow-up assessments were scheduled at 6, 12, 20, 28, and 48 weeks post-operatively. During these follow-up visits, clinical, radiological, and functional outcomes were meticulously recorded and evaluated based on the ASAMI score. The bone outcome was categorized as excellent, good, fair, or poor, based on criteria including union status, infection presence, degree of deformity, and LLD. Similarly, the functional outcome was classified as excellent, good, fair, poor, or failure, based on criteria

Annals of International Medical and Dental Research
E-ISSN: 2395-2822 | P-ISSN: 2395-2814
Vol-10, Issue-2 | March-April 2024
https://doi.org/10.53339/aimdr.2024.10.2.6
Page no- 48-57 | Section- Research Article (Orthopaedic Surgery)

such as activity level, presence of limp, stiffness, Reflex Sympathetic Dystrophy (RSD), pain, and the ability to return to daily activities or employment.

RESULTS

In this study of 12 patients, the age distribution showed a concentration in the 28-37 age group, representing 50% (6 patients) of the participants. The 38-47 age group followed with 25% (3 patients), the 18-27 age group with 16.67% (2 patients), and the 48-57 age group with 8.33% (1 patient). The average age was 34.4 years with a standard deviation of 9.09 years. Males were predominant in the study, comprising 75% (9 patients) of the participants, while females accounted for 25% (3 patients). Regarding the side of injury, the right side was more commonly affected, involving 66.67% (8 patients) of the cases, compared to the left side, which was involved in 33.33% (4 patients) of the cases. The majority of injuries were due to road traffic accidents, accounting for 83.33% (10 patients) of the cases, while falls from height were responsible for 16.67% (2 patients) of the injuries.

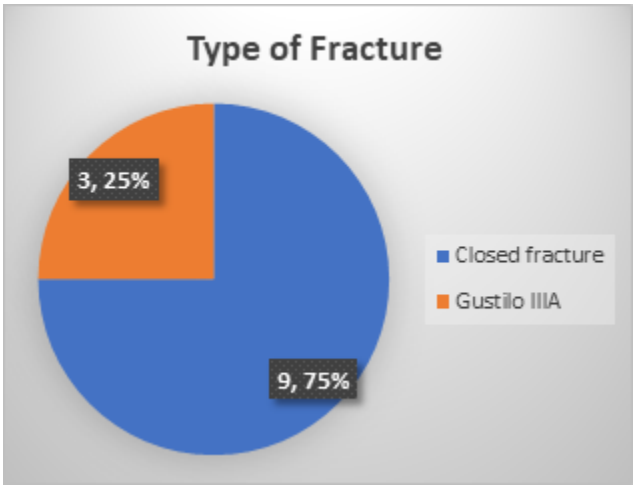

Figure 1: Distribution of type of fracture among the participants (N=12)

The majority of fractures were closed, with 9 cases accounting for 75% of the total. The remaining 25% (3 patients) were classified as open Gustilo IIIA fractures.

The Surgical Implant Generation Network (SIGN) Nail was the most common method of fixation, used in 66.67% (8 patients) of the cases. The Ilizarov External Fixator was employed in 25% (3 patients) of the cases. The least used method was the Plate & Screw fixation, applied in only 8.33% (1 patient) of the cases. [Table 2]

[Table 3] illustrates the interval between primary management and the application of the Masquelet Technique (MT) among the 12 study participants. The most common intervals were between 1-4 months and 5-8 months, each accounting for 41.67% (5 patients) of the cases. Less common were intervals of 9-12 months and 13-16 months, each representing 8.33% (1 patient) of the cases. The mean interval for the application of the Masquelet Technique following primary management was 6.37

Annals of International Medical and Dental Research
E-ISSN: 2395-2822 | P-ISSN: 2395-2814
Vol-10, Issue-2 | March-April 2024
https://doi.org/10.53339/aimdr.2024.10.2.6
Page no- 48-57 | Section- Research Article (Orthopaedic Surgery)

months, with a standard deviation of 4.12 months.

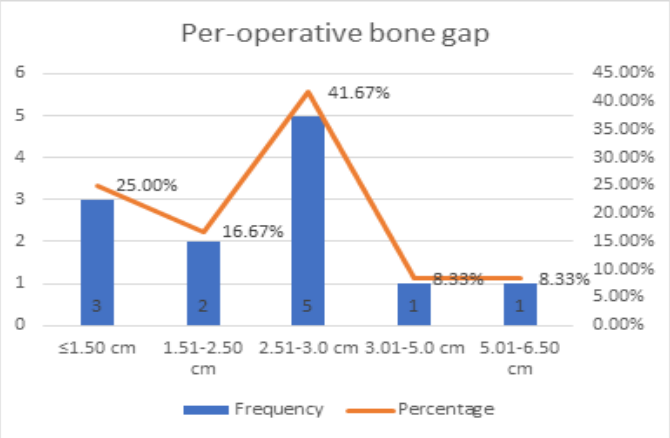

Figure 2: Distribution of participants according to per-operative bone gap (cm) (N=12)

[Figure 2] displays the distribution of the per-operative bone gap sizes among the 12 participants. The bone gaps varied, with the most common range being 2.51-3.0 cm, observed in 41.67% (5 patients) of the cases. Bone gaps of ≤1.50 cm were present in 25% (3 patients), while gaps measuring 1.51-2.50 cm were seen in 16.67% (2 patients) of the participants. Larger gaps, ranging from 3.01-5.0 cm and 5.01-6.50 cm, were less common, each found in 8.33% (1 patient) of the cases. The mean bone gap size was 3 cm, with a standard deviation of 1.40 cm.

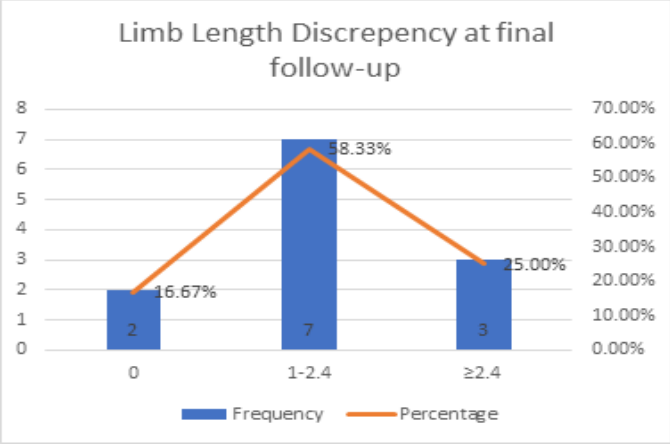

Figure 3: Distribution of participants by Limb Length Discrepancy at final follow up (N= 12)

[Figure 3] outlines the distribution of limb length discrepancy (LLD) among the 12 participants at their final follow-up. A total of 58.33% (7 patients) experienced an LLD ranging from 1 to 2.4 cm, making it the most common outcome. Notably, 16.67% (2 patients) achieved an ideal outcome with no limb length discrepancy (0 cm). However, a significant LLD of ≥2.4 cm was observed in 25% (3 patients) of the cases. The mean LLD across all participants was 1.83 cm, with a standard deviation of 1.15 cm.

[Table 4] presents the distribution of complications observed among the 12 participants in the study. The majority of the participants, 66.67% (8 patients), did not develop any complication. However, a significant proportion of the patients experienced various complications. Knee stiffness was the most common complication, affecting 33.33% (4 patients) of the participants. Pin tract infection was another notable complication, occurring in 16.67% (2 patients). Limp and pain were less frequent, each observed in 8.33% (1 patient) of the cases. It is

Annals of International Medical and Dental Research
E-ISSN: 2395-2822 | P-ISSN: 2395-2814
Vol-10, Issue-2 | March-April 2024
https://doi.org/10.53339/aimdr.2024.10.2.6
Page no- 48-57 | Section- Research Article (Orthopaedic Surgery)

important to note that some participants experienced overlapping complications, indicating the multifaceted challenges in the post-operative recovery process.

[Table 5] shows the bone outcomes at the final follow-up for the 12 participants. The majority, 66.67% (8 patients), achieved an 'Excellent' outcome, indicating successful bone union without significant complications. A 'Good' outcome, signifying successful union with minor issues, was observed in 25% (3 patients). Only one patient (8.33%) had a 'Fair' outcome, reflecting successful bone union but with more pronounced residual challenges.

[Table 6] outlines the functional outcomes of the participants at their final follow-up. The majority of the study group, 66.67% (8 patients), achieved an 'Excellent' functional outcome, indicating a high level of activity with minimal or no limitations. A 'Good' functional outcome, characterized by some limitations such as limp or stiffness, was observed in 25% (3 patients) of the cases. Only one patient, accounting for 8.33% of the study population, had a 'Fair' functional outcome

Table 1: Distribution of baseline characteristics among the participants (N=12).

Variables	Frequency	Percentage
Age		
18-27	2	16.67%
28-37	6	50.00%
38-47	3	25.00%
48-57	1	8.33%
Mean±SD	34.4±9.09	
Gender		
Male	9	75.00%
Female	3	25.00%
Side involved		
Right Side	8	66.67%
Left Side	4	33.33%
Mechanism of Injury		
Road Traffic Accident	10	83.33%
Fall From Height	2	16.67%

Table 2: Distribution of type of fixation among the participants (N=12).

Type of fixation	Frequency	Percentage
SIGN Nail	8	66.67%
Ilizarov Ex fixator	3	25.00%
Plate & screw	1	8.33%

Table 3: Distribution of participants according to Interval of Primary Management and Masquelet Technique (MT) (N=12).

Annals of International Medical and Dental Research
E-ISSN: 2395-2822 | P-ISSN: 2395-2814
Vol-10, Issue-2 | March-April 2024
https://doi.org/10.53339/aimdr.2024.10.2.6
Page no- 48-57 | Section- Research Article (Orthopaedic Surgery)

Interval of Primary Management to MT (months)	Frequency	Percentage
1-4	5	41.67%
5-8	5	41.67%
9-12	1	8.33%
13-16	1	8.33%
Mean±SD	6.37±4.12	

Table 4: Distribution of participants according to development of complications (N=12)

Complications	Frequency	Percentage
Absent	8	66.67%
Knee Stiffness	4	33.33%
Pin Tract Infection	2	16.67%
Limp	1	8.33%
Pain	1	8.33%

Table 5: Distribution of participants according to Bone outcome at final follow up

Bone Outcome	Frequency	Percentage
Excellent	8	66.67%
Good	3	25.00%
Fair	1	8.33%

Table 6: Distribution of participants according to Functional Outcome at final follow up

Functional Outcome	Frequency	Percentage
Excellent	8	66.67%
Good	3	25.00%
Fair	1	8.33%

DISCUSSION

The patient demographics in our study, focusing on younger adults with a concentration in the 28-37 age group (50%), and a male majority (75%), align with global trends in femoral shaft fractures. These findings are consistent with studies that have highlighted a higher incidence of femoral fractures in younger, predominantly male populations.[17,18,19] The predominance of injuries on the right side, observed in 66.67% of our cases, also mirrors patterns noted in other studies, suggesting a potential bias in the mechanism of injury or anatomical predispositions. Road traffic accidents, the leading cause of femoral shaft fractures in our study (83.33%), reflect the global epidemiology of these injuries, where high-energy trauma remains a primary cause.[20,21] This emphasizes the need for targeted interventions in road safety and trauma care. Most fractures in our study were closed (75.00%) (as they developed infected non-union after the primary surgery), and the Surgical Implant Generation Network (SIGN) Nail was the predominant fixation method (66.67%). This preference aligns with

Annals of International Medical and Dental Research
E-ISSN: 2395-2822 | P-ISSN: 2395-2814
Vol-10, Issue-2 | March-April 2024
https://doi.org/10.53339/aimdr.2024.10.2.6
Page no- 48-57 | Section- Research Article (Orthopaedic Surgery)

the shift towards intramedullary nailing, recognized for its efficacy in femoral shaft fracture management.[22] The varied intervals for applying the Masquelet Technique (MT), particularly between 1-4 months and 5-8 months, highlight the tailored approach in treatment, adhering to patient-specific needs and fracture characteristics.[23] The range of bone gap sizes in our study, particularly the common range of 2.51-3.0 cm, underscores the challenges in managing large bone defects. The mean bone gap size of 3 cm is significant, reflecting the severity of the fractures treated and aligning with findings from other studies that have documented similar challenges in managing large bone defects.[24] Limb Length Discrepancy (LLD) was a notable concern, with 58.33% of participants experiencing an LLD of 1 to 2.4 cm. Achieving no LLD in 16.67% of cases is a positive outcome, indicative of effective management strategies. Addressing LLD is crucial for functional recovery and minimizing long-term disability. Complications were relatively low in our study, with knee stiffness (33.33%) and pin tract infections (16.67%) being the most significant. These complications are consistent with those reported in other studies, emphasizing the importance of meticulous post-operative care.[25,26] The bone and functional outcomes in our study were predominantly positive, with 66.67% achieving 'Excellent' outcomes in both bone union and functional recovery. The presence of 'Fair' outcomes in a small proportion of participants highlights the ongoing challenges in managing complex femoral shaft fractures.

Limitations of the Study

The study was conducted in a single hospital with a small sample size. So, the results may not represent the whole community. The rarity of the ailment resulted in a very small sample size.

CONCLUSIONS

This study provides valuable insights into the management and outcomes of infected nonunion of femoral shaft fractures, particularly in the context of the Masquelet Technique. Our findings indicate a higher incidence of these fractures in young adults, predominantly males, with a significant number resulting from road traffic accidents. The use of the Surgical Implant Generation Network (SIGN) Nail emerged as the most common fixation method, demonstrating its effectiveness in treating these fractures. The study also highlighted the challenges in managing varying bone gap sizes and addressing limb length discrepancies, with a majority of patients achieving satisfactory bone and functional outcomes post-treatment. Despite some cases of complications like knee stiffness and pin tract infections, the overall success rate in terms of bone union and functional recovery was encouraging. These results underscore the importance of individualized treatment strategies and the potential of the Masquelet Technique in managing complex femoral shaft fractures, contributing to the ongoing efforts to enhance orthopedic trauma care.

Annals of International Medical and Dental Research
E-ISSN: 2395-2822 | P-ISSN: 2395-2814
Vol-10, Issue-2 | March-April 2024
https://doi.org/10.53339/aimdr.2024.10.2.6
Page no- 48-57 | Section- Research Article (Orthopaedic Surgery)

REFERENCES

1. Yang W, Wei Q, Wang H, Ding K, Li M, Li C, et al. Preoperative incidence and risk factors of deep venous thrombosis in patients with isolated femoral shaft fracture. BMC Surg. 2022;22(1):83.
2. Papapoulos S, Bone H, Cosman F, Dempster DW, McClung MR, Nakamura T, et al. Incidence of Hip and Subtrochanteric/Femoral Shaft Fractures in Postmenopausal Women With Osteoporosis in the Phase 3 Long-Term Odanacatib Fracture Trial. J Bone Miner Res. 2021;36(7):1225–34.
3. Byun SE, Shon HC, Park JH, Oh HK, Cho YH, Kim JW, et al. Incidence and risk factors of knee injuries associated with ipsilateral femoral shaft fractures: A multicentre retrospective analysis of 429 femoral shaft injuries. Injury. 2018;49(8):1602–6.
4. 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):e000203.
5. Hinton RY, Lincoln A, Crockett MM, Sponseller P, Smith G. Fractures of the femoral shaft in children. Incidence, mechanisms, and sociodemographic risk factors. J Bone Joint Surg Am. 1999;81(4):500–9.
6. Kurashina T, Fukui T, Oe K, Sawauchi K, Kuroda R, Niikura T. Management of Infected Non-union Following Femoral Shaft Fracture in a Patient with Klippel-Trenaunay Syndrome: A Case Report. J Orthop Case Rep. 2022;12(7):38–41.
7. Dilogo IH, Primaputra MRA, Pawitan JA, Liem IK. Modified Masquelet technique using allogeneic umbilical cord-derived mesenchymal stem cells for infected non-union femoral shaft fracture with a 12 cm bone defect: A case report. Int J Surg Case Rep. 2017;34:11–6.
8. Ueng SW, Wei FC, Shih CH. Management of femoral diaphyseal infected nonunion with antibiotic beads local therapy, external skeletal fixation, and staged bone grafting. J Trauma. 1999;46(1):97-103. doi: 10.1097/00005373-199901000-00016.
9. Kubes K, Friedman A, Pyle C, Diaz G, Hargett D. Management of twenty centimeter segmental bone defect of femoral shaft secondary to infected non-union of fracture using masquelet technique: A case report. Int J Surg Case Rep. 2021;84:106107.
10. Baker HP, Krishnan P, Foy M, Strelzow J, Daccarett M, Dillman D. Effect of nailing technique on length of stay in isolated ballistic femoral shaft fractures. Eur J Orthop Surg Traumatol. 2023;33(2):353–60.
11. Kalantar SH, Saffar H, Hoveidaei AH. Bone reconstruction with modified Masquelet technique in open distal femoral fractures: a case series. BMC Musculoskelet Disord. 2024;25(1):26.
12. Aljaafri ZA, Alzahrani A, Alshehri A, AlHussain A, Alzahrani F, Alsheikh K. Outcome of the Masquelet Technique for Complex Bilateral Distal Femoral Bone Defects. Cureus. 2023;15(5):e38503.
13. Miskiel SA, Caruso SA, Pagliaro AJ. Masquelet Technique for Hindfoot Fusion of Gustilo IIIA Open Ankle Dislocation with Complete Talar Extrusion and Loss. Foot Ankle Orthop. 2019;4(4):2473011419S00307.
14. Abd GF. Nonclassical Parametric Variational Technique to Manipulability Control of a Serial-Link Robot That Is Used in Treatment of Femoral Shaft Fractures. J Appl Math. 2023;2023:5575131:1-5575131:8.
15. El-Adly W, El-Gafary K, Khashaba M, Abubeih H. Flexible Intramedullary Nail Versus Submuscular Locked Plate with the Cluster Technique in Pediatric Femoral Shaft Fractures Fixation. Indian J Orthop. 2022;56(4):580–6.
16. Vicenti G, Bizzoca D, Carrozzo M, Nappi V, Rifino F, Solarino G, Moretti B. The ideal timing for nail dynamization in femoral shaft delayed union and non-union. Int Orthop. 2019;43(1):217-222. doi: 10.1007/s00264-018-4129-y.
17. Amin S, Achenbach SJ, Atkinson EJ, Khosla S, Melton LJ. Trends in Fracture Incidence: A Population-Based Study Over 20 Years. J Bone Miner Res. 2014;29(3):581–9.
18. Kayaokay K, Aktuglu K. Titanium elastic nailing in pediatric femoral diaphyseal fractures in the age group of 6-15 years mid-term and long-term outcomes. Pak J Med Sci. 2018;34(6):1529–33.
19. Singh DA, Aggarwal DRK, Sarad DR. To study the outcome of retrograde nailing in distal one-third femoral shaft fractures. Int J Orthop Sci. 2021;7(2):188–92.
20. Vicenti G, Carrozzo M, Caiaffa V, Abate A, Solarino G, Bizzoca D, et al. The impact of the third fragment features on the healing of femoral shaft fractures managed with intramedullary nailing: a radiological

Annals of International Medical and Dental Research
E-ISSN: 2395-2822 | P-ISSN: 2395-2814
Vol-10, Issue-2 | March-April 2024
https://doi.org/10.53339/aimdr.2024.10.2.6
Page no- 48-57 | Section- Research Article (Orthopaedic Surgery)

study. Int Orthop. 2019;43(1):193-200. doi: 10.1007/s00264-018-4214-2.
21. Enninghorst N, McDougall D, Evans JA, Sisak K, Balogh ZJ. Population-based epidemiology of femur shaft fractures. Journal of Trauma and Acute Care Surgery. 2013;74(6):1516.
22. Kim KH, Song G. Intramedullary Nailing for Atypical Femoral Fracture With Lateral Bowing: Does Medial Gap Matter? Geriatr Orthop Surg Rehabil. 2022;13:21514593211070130.
23. A Jaff H. Assessment of the outcome of early versus delayed spica cast in the treatment of closed femoral shaft fracture in children. Basrah Journal of Surgery. 2017;23(1):45–51.
24. Wang SI, Jeong HJ, Lim ST, Han YH. Prediction of leg-length discrepancy in pediatric femoral shaft fracture using bone SPECT/CT: A case report. Medicine (Baltimore). 2023;102(44):e35860.
25. Sanders DW, MacLeod M, Charyk-Stewart T, Lydestad J, Domonkos A, Tieszer C. Functional outcome and persistent disability after isolated fracture of the femur. Can J Surg. 2008;51(5):366–70.
26. Em D, Me U, Oa U. Adult traumatic femoral shaft fractures: A review of the literature. Ibom Medical Journal. 2012;5(1):26–38.

Source of Support: Nil, Conflict of Interest: None declared