Original Article
DOI: https://doi.org/10.70749/ijbr.v3i5.1233

INDUS JOURNAL OF BIOSCIENCE RESEARCH
https://induspublishers.com/IJBR
ISSN: 2960-2793/ 2960-2807

Functional Outcome of Monoplaner Exterrnal Fixation for Gustillo Anderson Type III Open Tibia Diaphysis Fractures

Shafi Ul Haq[1], Muhammad Qasim[1], Absar Khan[1], Muhammad Saeed[1], Muhammad Waqar[1]

[1]Orthopedic and Spine Unit, MTI-Hayatabad Medical Complex, Peshawar, KP, Pakistan.

ARTICLE INFO

Keywords: Monoplaner Exterrnal Fixation, Open Tibia Diaphysis Fractures, Bone healing, Soft Tissue Healing.

Correspondence to: Muhammad Qasim, Specialist Registrar, Orthopedic and Spine Unit, MTI-Hayatabad Medical Complex, Peshawar, KP, Pakistan.
Email: qasimkhan122@hotmail.com

Declaration
Authors' Contribution: All authors equally contributed to the study and approved the final manuscript.
Conflict of Interest: No conflict of interest.
Funding: No funding received by the authors.

Article History
Received: 04-01-2025, Revised: 11-04-2025
Accepted: 24-04-2025, Published: 08-05-2025

ABSTRACT

Introduction: Open fracture of tibia is a medical emergency that needs urgent management. Not properly managed open tibia fractures lead to permanent disability or even amputation The reported incidence of open fracture is 2.6% with 40% of which occurring in lower limbs. Tibia diaphysis is a common location for open skeletal fractures as there is scarcity of soft tissue and muscles antero-medially and its anatomy is such that it is more prone to injury.. No protocol and published data is available at our institutions on the management and long term outcome of such fractures. **Methodology:** This retrospective study has been conducted at Hayatabad Medical teaching institute orthopedic unit. The study duration was 03 years from 1st January 2021 to 31st December 2023 with 02 year follow-up. 215 patients with 226 fractures were included in the study that met the inclusion criteria. There were 147 males and 68 females. Age group of the patient was from 15-60 years. Mean age of the patients was 35.8 years. **Results:** Functional outcomes were assessed by to John and Wrus criteria 120 patients with type III tibia diaphysis fracture had excellent outcome, 72 out of 226 fractures had good outcome, 29 fractures resulted in fair category, 3 in poor and 2 resulted in amputation of the limb. **Conclusion:** The study results suggested that Bone healing and soft tissue healing time were strongly correlated with the functional outcome of open tibia diaphysis fracture. Mean bone healing time was 14 weeks.

INTRODUCTION

Open fractures of the lower limb especially tibia resulting from road traffic accidents or fall is a common presentation to accident emergency department [(1)]. Open fracture of tibia is a medical emergency that needs urgent management. Not properly managed open tibia fractures lead to permanent disability or even amputation.

The reported incidence of open fracture is 2.6% [(1)] with 40% of which occurring in lower limbs [(3, 5).] 23.5% of tibia fractures are reported to be communicating with wound. Tibia diaphysis is a common location for open skeletal fractures as there is scarcity of soft tissue and muscles antero-medially and its anatomy is such that it is more prone to injury [(03, 13,15)]. Grade III open fractures usually result from high energy trauma with significant damage to soft tissue coverage and bony components as well [(5)]. Due to less soft tissue coverage open tibia fractures result in complications like wound complications infection, COM, mal-union and non-union [(1, 2, 13, 14,15)]. Infection rate of as high as 11-38% has been reported, likewise non-union 07-6-% and 100 % need for second surgery has been quoted in studies [(11)].

Open fracture is an emergency that should be managed on urgent basis with antibiotic coverage, wound care and stabilization [(4)]. The aim of open tibia fracture management is bony union with acceptable alignment of the limb and soft tissue healing without complications so that final functional outcome is more productive [(14,16)]. Patient should be managed according to advance trauma life support (ATLS) protocol starting with assessment and concomitant management [(07)]. Intravenous antibiotics administration should be initiated as soon as possible after identifying open fracture preferably within first hour [(06)]. The British Infection Society and the Association of Medical Microbiologists have advocated antibiotics prophylaxis for open fracture management [(5)]. 59% reduction in infection development is reported with intravenous antibiotic administration [(8)]. Antibiotic therapy, early debridement and fracture stabilization is paramount in managing these patients [(10, 13)]. Previously 06 hour golden period for debridement was believed. However, several studies have challenged the traditional '6-hour' window, finding no correlation between the

timing of debridement and the rate of infection [9, 11, and 12]. Timely soft tissue management along with external fixator for bony stability is the optimal management option in open tibia fractures [16]. Surgical debridement should not be performed outside Operation Theater [06].

Classifications commonly used for these fracture are Gustilo – Anderson and the AO (Arbeitsgemeinschaft für Osteosynthesefragen) Orthopedic Trauma Association Open Fracture Classification (OTA-OFC) systems. The Gustilo-Anderson classification is more practical and prognostic and used more often [13, 14]. Type I Gustilo-Anderson tibia shaft fractures result from low energy and having simple fracture pattern with ≤1cm clean wound ; Type II fractures also results from low energy trauma with laceration greater than 1 cm and up to 10 cm long without extensive soft tissue involvement. Type III Gustilo-Anderson tibia fractures are high energy trauma and further subdivided into 03 types. Type IIIA open fractures have extensive soft tissue damage but coverage is possible without grafting, Type IIIB fracture are labeled when soft tissue coverage is not possible due to soft tissue loss and needs grafting. This usually is associated with massive contamination. When fractures are associated with major arterial injury that needs repair are labeled as type IIIC Gustilo-Anderson [13, 14]. Intramedullary is the practice used Type I and II Gustilo-Anderson open tibia fracture but external fixation is the proposed option for Type III Gustilo-Anderson open tibia fracture[3].

Skeletal stabilization primarily restores the acceptable limb alignment; provide the opportunity of soft tissue damage management and early resumption of limb function [13]. Bony fixation has decrease the infection development [13].Traction or long plaster slabs are not recommended for provisional stabilization [6]. Fracture stabilization utilizing external fixation needs little tissue dissection and thus prevents further damage to already compromised soft tissue [15]. Consensus is there on external fixation as internal fixation has been resulted in many complications in literature [3, 16] although intramedullary nailing has also been suggested in type IIIA fractures. Loss of reduction, pin tract infection, delayed union, non-union has been associated with external fixation of bone but somehow these problems has been reduced with circular external fixation devices [16]. But the availability of these circular or hexapodal frames and their surgery time doesn't always allow its application in emergency situation [16].

No protocol and published data is available at our institutions on the management and long term outcome of such fractures as some advocate conversion of external fixator to internal fixation after wound healing while others are in favor of continuing the ex-fix till bone healing and avoiding further surgeries.

The purpose of this study is to determine the functional and radiological outcome of type III open tibia diaphysis fractures managed with mono-planer external fixator.

METHODOLOGY

This retrospective study has been conducted at Hayatabad Medical teaching institute orthopedic unit. The study duration was 03 years from 1st January 2021 to 31st December 2023 with 02 year follow-up. 215 patients with 226 fractures were included in the study that met the inclusion criteria. There were 147 males and 68 females. Age group of the patient was from 15-60 years. Mean age of the patients was 35.8 years. Patients with open tibia diaphysis fracture that fall into gustilo-Anderson type 3A/3B/3C were included in the study. poly-trauma and previously ill patients were excluded from the study. Total of 215 patients met the inclusion criteria. 126 out of 226 fractures were type IIIA, 94 fractures were type IIIB and 06 fractures were type IIIC.

All patients presented to the emergency department with type III Gustilo-anderson open tibia diaphysis fracture were assessed and managed according to ATLS protocol. Infection prophylaxis and tetanus prophylaxis were administered in emergency department. Splint was applied and shifted to OT on priority basis. Thorough debridement was carried out in Operation Theater under spinal anesthesia. Wash of the wound was done with 6L normal saline. Mono-planar external fixators were applied in all open tibia diaphysis fractures. Primary closure was done in type 3A open fractures while delayed skin grafting were carried out in type 3b cases. Bone coverage was done with saline soaked gauzes and bactigrass dressing. Skin grafting was performed in 1st week after wound status become satisfactory. Large flaps or sking grafting were performed by plastic surgery colleagues while split thickness skin grafting were performed by orthopedic surgeons. Vascular colleagues help was obtained in cases with type 3C fractures.

25 cases required bone grafting where bone loss was extensive. Bone grafting was done once the wound healing was completed mostly after 4 weeks.

Repeat debridement was carried out where needed. IV antibiotics were continued for 2 weeks. External fixators were removed after average of 24.5 weeks. Patients were followed for 02 years after removal of fixators and were assessed on modified johner and wruhs criteria for functional and radiological outcome. Radiological outcome was assessed by bone healing signs on X-rays. Modified Johner and wruhs criteria [17]

Criteria	Excellent	Good	Fair	Poor
Non-union/ infection	None	None	None	yes
Neurovascular injury	None	Mini	Mod	Severe
Deformity				

Varus/Valgus	None	2-5	6-10	>10 degree
Ant/Posterior	0-5	6-10	11-20	>20 degree
Shortening	0-5	6-10	11-20	>20mm
Mobility				
Knee	Full	>90	90-75	<75%
Ankle	Full	>75	75-50	<50%
Pain	None	Occasional	Moderate	Severe
Gait	Normal	Normal	Mild Limp	Significant Limp

RESULTS

Type IIIA Fractures

Type 3A tibial fracture outcomes were satisfactory with only 10 resulting complications. Complications were in the form of superficial infection. Wound infection was` managed with repeat debridement and antibiotic cement beads. 69% of these fractures healed uneventfully having excellent outcome according modified johner and wrus criteria. 25% were in good category while 06% were having fair outcome. No case ended with poor outcome or amputation.

Mean union time was 10.5 weeks

Type IIIB Fractures

Outcome for type 3B tibia fractures were not that much satisfactory as compared to type 3A with mean union time of around 14 weeks and complication rate of 32% (7 out of 22). Functional outcome was less satisfactory as compared to type IIIA fracture. 33 (35%) had excellent results, 40(42%) had outcome in good category, 19(20%) patient in fair category, while 3% in poor category. 34 patients were having infection which repeats debridement. 2 of wounds healed after repeat debridement and 2 needed antibiotic cement beads placement which were removed after 2 weeks. Skin grafting was needed in 14 patient flap coverage was done in 8 patients. 3 patients developed complication in the form of graft infection and dehiscence, which were re-grafted after debrided.

Type IIIC

Type 3c fractures were having worst outcome as one cases ended in amputation, 02 (40%) patients with type IIIC tibia fracture ended in chronic osteomyelitis that needed repeated debridement and antibiotic cement beads and the result was poor. This resulted in prolonged application of the fixator for around 9 months. The 3rd case outcome was acceptable although union rate was delayed as compared to type 3b and 3a and resulted in good outcome. 2 patients with vascular injury presented to emergency department after 12 hours of the injury as they were referred from other areas resulted in amputation. Vascular repairs done by vascular colleagues, prophylactic fasciotomies were performed at the time of repair but signs of gangrenes aggravated and amputation was done on next list.

Table 1

Cross Table for Dependent Gustillo-Anderson_type and bone healing

	N	3A	3B	3C	Test Statistic
		(N=126)	(N=95)	(N=5)	
Bone healing time(weeks)	223	9.5 **12.0** 10.5	11.0 **15.0** 14.0	13.0 **19.0** 16.5	$F_{2,220}$=9.62, P<0.01[1]

The table presents the bone healing time for each group (3A, 3B, 3C) in weeks. It lists the median healing time for each group, based on the number of non-missing values (N).

3A (N = 126):

Median: 10.5 weeks

The 25th percentile is 9.5 weeks, and the 75th percentile is 12.0 weeks.

3B (N = 95):

Median: 14.0 weeks

The 25th percentile is 11.0 weeks, and the 75th percentile is 15.0 weeks.

3C (N = 5):

Median: 16.5 weeks

The 25th percentile is 13.0 weeks, and the 75th percentile is 19.0 weeks.

Figure 1

Relation of type of Injury and Bone healing time in weeks

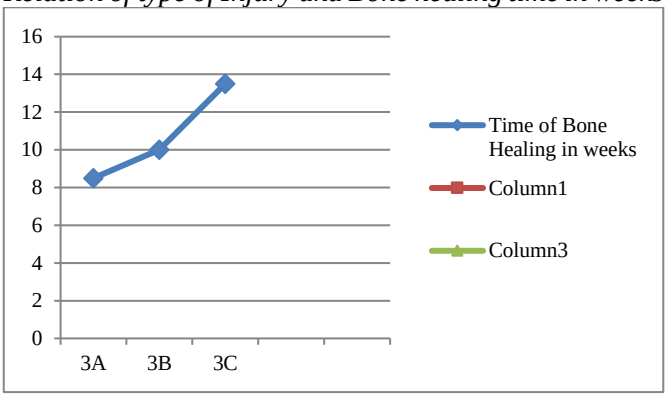


Table 2

Dwass-Steel-Critchlow-Fligner pairwise comparisons

Pairwise comparisons - bone healing time(weeks)			
		W	p
3A	3B	4.82	0.002
3A	3C	3.41	0.042
3B	3C	2.44	0.196

The Kruskal-Wallis test showed a significant overall difference in bone healing time between at least two of the groups.

Pairwise comparisons revealed:

3A vs 3B: Significant difference (p = 0.002), suggesting the bone healing time in 3A is significantly different from 3B.

3A vs 3C: Significant difference (p = 0.042), suggesting the bone healing time in 3A is significantly different from 3C.

3B vs 3C: No significant difference (p = 0.196), indicating that 3B and 3C have similar bone healing times.

Thus, 3A has significantly different healing times compared to both 3B and 3C, but 3B and 3C do not differ significantly from each other.

Table 3

Contingency Tables

	Gustillo Anderson Type			
John & Wrus Criteria	**3A**	**3B**	**3C**	**Total**
Excellent	87	33	0	120
Good	31	40	1	72
Fair	8	19	2	29
poor	0	3	0	3
Amputation	0	0	2	2
Total	126	95	5	226

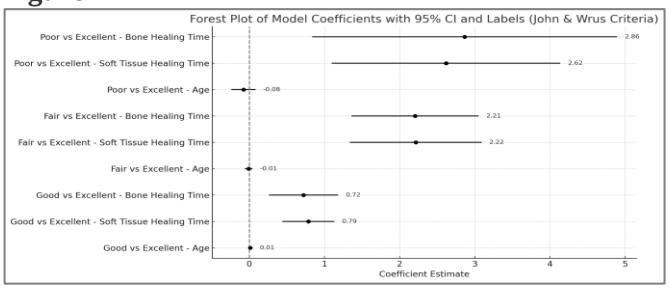
This means that the type of injury significantly influences the John & Wrus classification (Excellent, Good, Fair, Poor, Amputation).

Table 4

Model Coefficients - John & Wrus Criteria

John & Wrus Criteria	Predictor	Estimate	SE	Z	p
Good - Excellent	Intercept	-7.73196	1.5589	-4.960	<.001
	Age	0.01185	0.0130	0.913	0.361
	Soft tissue healing time(weeks)	0.78640	0.1769	4.444	<.001
	Bone healing time(weeks)	0.72183	0.2350	3.071	0.002
Fair - Excellent	Intercept	-24.54129	3.7226	-6.592	<.001
	Age	-0.00900	0.0254	-0.354	0.723
	Soft tissue healing time(weeks)	2.21525	0.4470	4.955	<.001
	Bone healing time(weeks)	2.20550	0.4308	5.119	<.001
Poor - Excellent	Intercept	-32.53135	9.4350	-3.448	<.001
	Age	-0.07798	0.0819	-0.952	0.341
	Soft tissue healing time(weeks)	2.61706	0.7769	3.368	<.001
	Bone healing time(weeks)	2.86392	1.0353	2.766	0.006
Amputation - Excellent	Intercept	.	.	.	.
	Age	.	.	.	.
	Soft tissue healing time(weeks)	.	.	.	.
	Bone healing time(weeks)	.	.	.	.

Figure 2



Age is not significant in any category (p > 0.3).

Soft tissue healing time and bone healing time are significant predictors for all categories.

Longer healing times for both soft tissue and bone are associated with worse outcomes (Good, Fair, and Poor vs. Excellent).

Regression suggests that early healing of both soft tissue and bone is associated with better functional outcomes (i.e., "Excellent").

Table 5

Bone and osteomyelitis

		Statistic	p
Bone healing time(weeks)	**Mann-Whitney U**	770	<.001

Note. H_a $\mu_{no} \neq \mu_{yes}$

The Mann-Whitney U test indicates that bone healing time is significantly affected by whether or not the patient has osteomyelitis(variable name used in data set) , with a p-value < 0.001 supporting this conclusion.

Table 6

Contingency Tables

	Mechanism of injury					
John & Wrus Criteria	**RTA**	**Fire arm injury**	**Fall from height**	**Heavy object fall**	**Crush injury**	**Total**
Excellent	78	24	18	0	0	120
Good	46	19	0	7	0	72
Fair	10	11	0	0	8	29
poor	1	2	0	0	0	3
Amputation	1	0	0	0	1	2
Total	136	56	18	7	9	226

Table 7

χ^2 Tests

	Value	df	p
χ^2	99.9	16	<.001
N	226		

Table 8

Nominal

	Value
Contingency coefficient	0.554
Phi-coefficient	NaN
Cramer's V	0.332

The Chi-Squared Test with a p-value < 0.001 indicates a statistically significant relationship between Mechanism of Injury and John & Wrus Criteria.

Table 9

Contingency Tables

	infection		
John & Wrus Criteria	**no**	**yes**	**Total**
Excellent	95	21	116
Good	31	41	72
Fair	4	25	29
poor	0	3	3
Amputation	0	2	2
Total	130	92	222

Table 10
χ^2 Tests

	Value	df	p
χ^2	64.2	4	<.001
N	222		

The Chi-square test suggests that infection status is associated with the distribution of individuals across the different John & Wrus Criteria categories.

Since the p-value is very small (< 0.001), this indicates that the association is statistically significant. Thus, infection status is likely to influence the outcome, as categorized by the John & Wrus Criteria

DISCUSSION

Our study results show encouraging results with the use of external fixator in type III Gustilo-Anderson tibia fracture. Mono-planar external fixators are readily available, easy to apply, less time consuming, and provide adequate support to maintain fracture reduction until bone healing occurs. Moreover tissue management is more convenient with in situ external fixator. The fixator is less cumbersome for the patient as is lighter in weight. Most of the time the direction of its application is antero-posteriorly, this enables the patient to change sides while in bed. Pin site care is also hassle free.

All fractures united with bone grafting required in 25 (11%) of the cases. superficial infection developed in 92 (40%) cases that was managed by repeated debridement. On the average 4 sessions of debridement required management of superficial infection management.

Naique et al. compared the union time in open tibial dia-physeal fracture managed with intra-medullary nailing and external fixation. Time of healing and deep infection was not statistically significant in two groups [(12)]. Study by *Al-Sayyad MJ* mean healing time in circular frame was 25 weeks which is near to healing time in our study [(16)].

Webb et al. demonstrated in their comparative study that, in cases of type III open tibia diaphysis fractures not requiring flap coverage for wound management, there was no significant difference in functional outcomes whether managed with external fixation or intramedullary nailing. According to their study results patient treated with intra-medullary nailing however had short hospital stay, early weight bearing and less number of surgical procedures. But these advantages were partly because of open fracture characteristics. Intramedullary nailing was used in fractures where there was minimal soft tissue damage [(11)].

The strong predictor of the outcome of mono-planer external fixator in type III open tibia fracture is type of injury. Type IIIC tibia fracture had the worst functional outcome measured by John and Wrus criteria. Similar results were quoted by Malik Çelik et al. in their study on open tibia fractures [(18)].

According to this study results Bone healing and soft tissue healing time were strongly correlated with the functional outcome of open tibia diaphysis fracture. Mean healing time was 14 weeks which is well close to the results showed in the study by Malik Celik et al. [(18).]

Regarding timing of wound debridement, no significant difference was observed in our study. Naique et al. study also reported similar infection rate in both group though infection rate was slightly high in those debridement was done after 12 hour of injury [(12)].

Conclusion

Functional outcome in open tibia diaphysis fracture managed by mono-planer external fixator is dependent on type of injury and bone and soft tissue healing time. The patient convenience, less cost availability of the implant, and lesser surgical time required for its application in emergency situation makes it a good option for open tibia fractures. Limitation of the study is the type of management done before presentation to our emergency department for open tibia diaphysis fracture. No conflict of interest is there.

REFERENCES

1. Nicolaides, M., Pafitanis, G., & Vris, A. (2021). Open tibial fractures: An overview. *Journal of Clinical Orthopaedics and Trauma*, *20*, 101483. https://doi.org/10.1016/j.jcot.2021.101483
2. Hao, Z., Xia, Y., Xia, D., Zhang, Y., & Xu, S. (2019). Treatment of open tibial diaphyseal fractures by external fixation combined with limited internal fixation versus simple external fixation: A retrospective cohort study. *BMC Musculoskeletal Disorders*, *20*(1). https://doi.org/10.1186/s12891-019-2679-9
3. Hohmann, E., Birkholtz, F., Glatt, V., & Tetsworth, K. (2017). The "Road to union" protocol for the reconstruction of isolated complex high-energy tibial trauma. *Injury*, *48*(6), 1211-1216. https://doi.org/10.1016/j.injury.2017.03.018
4. Griffin, M., Malahias, M., Khan, W., & Hindocha, S. (2012). Update on the management of open lower limb fractures. *The Open Orthopaedics Journal*, *6*(1), 571-577. https://doi.org/10.2174/1874325001206010571
5. Dickson, D., Moulder, E., Hadland, Y., Giannoudis, P., & Sharma, H. (2015). Grade 3 open tibial shaft fractures treated with a circular

frame, functional outcome and systematic review of literature. *Injury*, *46*(4), 751-758. https://doi.org/10.1016/j.injury.2015.01.025
6. British Association of Reconstructive and Aesthetic Surgeons. Standards for treatment of open fractures of the lower leg. 2009
7. ACoSCo, T. (2012). Advanced trauma life support student course manual. *Chicago: American College of Surgeons*.
8. Gosselin, R. A., Roberts, I., & Gillespie, W. J. (2004). Antibiotics for preventing infection in open limb fractures. *Cochrane Database of Systematic Reviews*, (1). https://doi.org/10.1002/14651858.CD003764.pub2
9. Crowley, D. J., Kanakaris, N. K., & Giannoudis, P. V. (2007). Irrigation of the wounds in open fractures. *The Journal of Bone & Joint Surgery British Volume*, *89*(5), 580-585. https://boneandjoint.org.uk/article/10.1302/0301-620X.89B5.19286
10. Kindsfater, K., & Jonassen, E. A. (1995). Osteomyelitis in grade II and III open tibia fractures with late debridement. *Journal of Orthopaedic Trauma*, *9*(2), 121-127. https://doi.org/10.1097/00005131-199504000-00006
11. Webb, L. X., Bosse, M. J., Castillo, R. C., & MacKenzie, E. J. (2007). Analysis of surgeon-controlled variables in the treatment of limb-threatening Type-III open tibial Diaphyseal fractures. *The Journal of Bone and Joint Surgery-American Volume*, *89*(5), 923-928. https://doi.org/10.2106/00004623-200705000-00001
12. Naique, S. B., Pearse, M., & Nanchahal, J. (2006). Management of severe open tibial fractures. *The Journal of Bone and Joint Surgery. British volume*, *88-B*(3), 351-357. https://doi.org/10.1302/0301-620x.88b3.17120
13. Manjra, M., Basson, T., Du Preez, G., Du Toit, J., & Ferreira, N. (2019). Current concepts in the management of open tibia fractures. *SA Orthopaedic Journal*, *18*(4). https://doi.org/10.17159/2309-8309/2019/v18n4a7
14. Kim, P. H., & Leopold, S. S. (2012). Gustilo-Anderson Classification. *Clinical Orthopaedics and Related Research*, *470*(11), 3270–3274. https://doi.org/10.1007/s11999-012-2376-6
15. Kim, P. H., & Leopold, S. S. (2019). Erratum to: In brief: Gustilo-Anderson classification. *Clinical Orthopaedics & Related Research*, *477*(10), 2388-2388. https://doi.org/10.1097/corr.0000000000000950
16. Liu, Y., Liu, K., Cai, F., Zhang, X., Li, H., Zhang, T., Ma, C., & Yusufu, A. (2022). Retrospective clinical outcomes in the definitive treatment of high-energy tibial diaphyseal fractures using hexapod external fixator versus monolateral external fixator. *BMC Musculoskeletal Disorders*, *23*(1). https://doi.org/10.1186/s12891-022-05257-1
17. Al-Sayyad, M. (2008). Taylor spatial frame in the treatment of open tibial shaft fractures. *Indian Journal of Orthopaedics*, *42*(4), 431. https://doi.org/10.4103/0019-5413.43393
18. Batta, V., Dwyer, A. J., Gulati, A., Prakash, J., Mam, M. K., & John, B. (2012). No difference in the long term final functional outcome after nailing or cast bracing of high energy displaced tibial shaft fractures. *Journal of Trauma Management & Outcomes*, *6*(1). https://doi.org/10.1186/1752-2897-6-5
19. Çelik, M., Bayrak, A., Öztürk, V., Kızılkaya, C., & Avkan, M. C. (2024). Functional and radiological comparison and evaluation of Gustilo-Anderson type 3 open tibia fractures treated with an Ilizarov external fixator. *Bakirkoy Tip Dergisi / Medical Journal of Bakirkoy*, *20*(4), 308-314. https://doi.org/10.4274/bmj.galenos.2023.2023.9-1