EXTERNAL FIXATION FOLLOWED BY CAST IMMOBILIZATION IN THE MANAGEMENT OF GUSTILO-ANDERSON IIIA AND IIIB OPEN TIBIAL FRACTURES

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ABSTRACT

Background: The ideal method for definitive management of open tibia fractures has been a subject of debate. Several techniques have been tried with mixed results.

Objectives: To describe and present our experience using external fixator interrupted by cast immobilization in the management of Gustillo-Anderson IIIA and IIIB open tibia fractures guided by the radiographic union scale of tibia fractures.

Methods: Patients with Gustillo-Anderson IIIA and IIIB tibia fractures admitted into Nnamdi Azikiwe University Teaching Hospital had debridement and stabilization with external fixators. Subsequently, fracture healing was monitored with radiographs while wounds were cared for with dressings. At Radiographic Union Scale for Tibial Fractures (RUST) score of 4, external fixators were taken down and above knee plaster of Paris cast applied. Partial weight bearing was commenced at RUST 6 (cast still in place). Cast was removed at RUST 11 and full weight bearing commenced at RUST 12. Outcome of this method was assessed.

Results: Gustillo-Anderson IIIA accounted for 43.1% while IIIB accounted for 56.9%. Mean presentation-intervention interval was 41.5 hours ±3.3. Mean time to partial weight bearing was 14.2 weeks ±1.8 (GA IIIA) and 15.6 weeks ±2.6 (GA IIIB). Mean duration on cast was 12.4 weeks (GA IIIA) and 17.5 weeks (GA IIIB). Union occurred at a mean time of 29.9 weeks (GA IIIA) and 35.6 weeks (GA IIIB). Polymicrobes were seen in both classes. Non union rate was 17.6%.

Conclusions: Management of open tibia fractures with external fixator and conversion to cast immobilization results in good healing. Presentation-intervention interval of close to 48 hours does not significantly affect pin tract infection rates. RUST is a useful guide for safe graduation of patients with tibia fractures across the stages of treatment rehabilitation.

Key words: Cast, External fixator, Gustillo-Anderson, Fracture, Tibia

INTRODUCTION

Fractures are said to be open when the fracture site communicates with the external environment through a skin breech (1). There are between 3.5 million to 6 million fractures in the United States of America; 3% of which are open fractures (2,3). Open tibia fractures account for over 40% of all open fractures (4). The Gustilo and Anderson classified open fractures into three groups based on the size of the soft tissue defect, degree of contamination, extent of bone exposure/fragmentation and involvement of vessels requiring repair. The third group is further subdivided into three subgroups. Type I are fractures with an open wound less than 1cm, minimal soft tissue contamination and minimal soft tissue damage. Type II includes fractures with laceration greater than 1cm but less than 10cm, moderate soft tissue damage, adequate bone coverage and minimal comminution. Type IIIA are fractures with lacerations greater than 10cm, extensive soft tissue damage, adequate bone coverage, segmental or severely comminuted fractures or heavily contaminated wounds. Type IIIB involves type IIIA fractures with associated periosteal stripping and bone exposure. Type IIIC are open fractures with vascular injury requiring repair.

Open fractures are generally challenging to treat. Before the advent of antibiotics and established wound management techniques, amputation represented the way out of open fractures especially those with fulminant sepsis that are a threat to life (5). Open fractures are surgical emergencies. The combined effect of periosteal stripping and compromise of blood supply creates a high risk for bone desiccation and non union. In addition, soft tissue injuries and contamination at the injury site makes the wound prone to infection and puts the patient at risk of sepsis. The principles of treatment generally include: prompt wound irrigation and debridement, early commencement of intravenous antibiotics and fracture stabilization after achieving a good reduction (6,7). Wound care protocol in open fractures depends on the state of the soft tissues surrounding the fracture site and generally ranges from debridement and primary closure to delayed closure (8). Delayed closure may involve secondary wound closure or skin grafting. Flap coverage is yet another option which can be done at the time of initial wound exploration and debridement and represents the modality of choice for wound coverage especially in open fractures where bone exposure is usually the case.

The ideal option for definitive management in open tibia fractures has been a subject of debate (9-11). Initial stabilization with external fixation alongside wound closure followed by intramedullary nailing at a later date is quite common. It however has the drawback of need for several operations, lengthened period of immobilization, prolonged hospital stay and the financial/economic implications on the patient (6). External fixation in combination with limited internal fixation using cortical screws or Kirschner wires has also been suggested (12-16). The extra metalwork leaves the patient at a considerably higher risk of infection especially in the face of an open injury (7). Linear rail system alone is another useful alternative for the advantage of early mobilization and shortened hospital stay (6). However, the prolonged period the Schanz screws of the linear rail system stays *in situ* poses the same problem of infection. There is also the option of using external fixator alone; but this has the problem of poor union, unsatisfactory alignment and thus the need for unforeseen subsequent surgeries (10,12,17).

Studies showing the use of external fixator interrupted by cast immobilization to shorten the period of external fixation as a means of averting the potential complications of open fractures have not been explored in detail based on available literature. In addition, it is generally accepted principle that open fractures should be treated within the golden hours-6 hours. Some studies have however shown that debridement done beyond 6 hours did not increase infection rate nor did time to definitive treatment predict union (18,19). Furthermore, there is limited information describing the length of time it takes tibia fractures to heal (20). This study aims to present our experience using external fixator followed by cast immobilization as a method of definitively managing open tibia fractures of the Gustilo and Anderson class IIIA and IIIB.

MATERIALS AND METHODS

Study design: The study was performed from 1st January 2013 to 31st December 2022. All patients admitted into the Accident and Emergency Unit of Nnamdi Azikiwe University Teaching Hospital and who gave their consent and met the inclusion criteria were involved in the study. Inclusion criteria were all adults aged 18-65 years, with Gustillo and Anderson type IIIA and IIIB tibia shaft fractures, that were clear of the articular surface by a distance of at least 6cm. Patients with prior fractures of the tibia, those with co-existing life threatening injuries brought about by the same mechanism that caused the open tibia fractures, closed fractures, patients younger than 18 years and Gustillo and Anderson I, II and IIIc were excluded from the study.

Pre-operative workup: All patients had an initial wound care in the emergency room that comprised wound irrigation with 6litres of normal saline or until wound was grossly clean. They subsequently had wound dressings with Edinburgh University Solution of Lime (EUSOL). Tetanus prophylaxis and intravenous antibiotics comprising ceftriaxone and metronidazole were administered. Radiographs of the injured limb were taken in antero-posterior and lateral views. Wound swabs were taken 24-48 hours from presentation.

Intervention: All patients were taken to theatre at the earliest possible time and had debridement and stabilization with external fixators. In the interval before surgery wounds were dressed with EUSOL and normal saline. Spinal anaesthesia was used for all surgeries and skin preparation was done by cleaning twice with chlorhexidine-cetrimide solution, dried and painted with povidone iodine. All surgeries were conducted by consultants or senior residents. Wounds were first debrided extensively and irrigated with normal saline. Fractures were reduced and stabilization done with external fixators. In mounting the external fixator, two holes were predrilled using 3.5mm drill bit on either side of the fracture site at points farthest away from the fracture site to permit acceptance of the connecting rod length. Schanz screws were then passed manually through the pre-drilled holes using a T-handle with Chuck. Clamps were then connected to the Schanz screws and a connecting rod mounted with sufficient clamps in between to accept extra Schanz screws. An extra rod was added if better stability was needed. Extra holes were pre-drilled on either side of the fracture site through the holes in the clamps placed in between. Schanz screws were passed through the pre-drilled holes in a similar fashion. All Schanz screws purchased two cortices of the tibia. Bolts on the clamps were locked using a rench beginning with the clamps closest to the fracture site. Wound was tagged and limited soft tissue reconstruction was done that was sufficient to ensure bone was not exposed, except where this was not possible by virtue of the presence of extensive soft tissue injuries. Pin tracts were dressed with povidone iodine and wounds with EUSOL.

Post operative care: Post operatively wounds were dressed daily with EUSOL and pin tracts with povidone iodine once daily. Swabs were taken weekly from the wound core and from the pin tracts at their point of entry to the skin. Patients were mobilized non weight bearing on a pair of axillary crutches while wounds were being cared for. Periodic radiographs were used to monitor for progress with bone healing. External fixators were removed at a score of 4 on the Radiographic Union Scale for Tibial fractures (RUST). Removal of external fixator was meticulously done over a cast as follows. A vel band was rolled around the affected leg through the spaces in between each Schanz screw beneath the connecting rod. Preliminary layers of cast were then applied over the vel band. Clamps were loosened using a rench and connecting rod removed. Extra layers of plaster of Paris were then applied in similar fashion and Schanz screws detached beginning with screws farthest away from the fracture site. A re-enforcing layer of cast was applied over the holes left by the Schanz screws. Immediate check X-rays were done to assess for displacement. Windows were cut in the cast for patients with wounds still requiring dressings. Partial weight bearing was commenced at RUST 6 with cast still *in situ* (and a heel pad applied). Casts were removed at RUST 11 and full weight bearing commenced at RUST 12. Cases of non union had re-fixation at variable dates when all wounds had healed and no evidence of infection seen.

RESULTS

Seventy four patients with Gustillo-Anderson IIIA or B fractures were seen in the emergency room but only 51 consented to be part of the study. There were 36 males and 15 females (70.6% and 29.4% respectively). The mean age was 39.7 (±12.4). Passenger Motorcycle Road Traffic Accident (PMCRTA) accounted for 56.9% while falls from heights and missile injuries accounted for 3.9% each (Table 1). Gustillo-Anderson IIIA accounted for 43.1% while type IIIB accounted for 56.9% (Table 2). The mean presentation-intervention interval was 41.5 hours (± 3.3) (Table 3). The mean time to partial weight bearing was 14.2 weeks (±1.8) for GA IIIA and 15.6 weeks (±2.6) for GA IIIB. Mean duration on cast was 12.4 weeks for GA IIIA and 17.5 weeks for GA IIIB. Union occurred at a mean time of 32.9 weeks ±6.2.

Figure 1

Clinical photograph of the leg of a patient with an open tibia fracture after debridement and stabilization with an external fixator

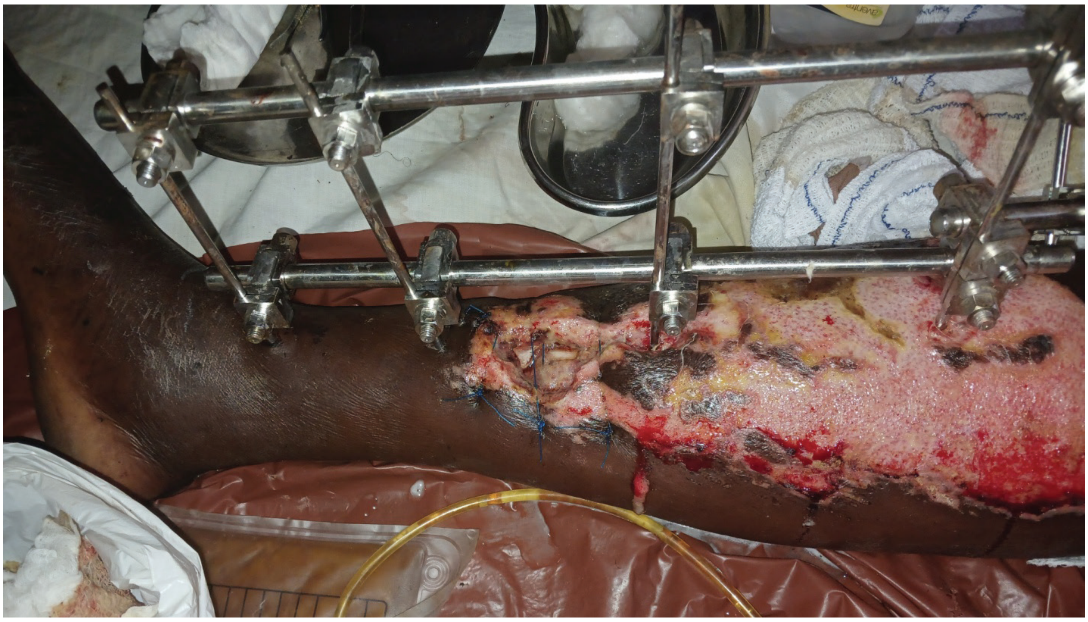

Figure 2

Sample of Radiographic Union Scale for Tibial Fractures (RUST) used in this study

Cortex	Visible fracture line without callus score 1	Visible fracture line with callus score 2	No fracture line with visible callus score 3	Total Min 4 Max 12
Lateral cortex				
Medial cortex				
Anterior cortex				
Posterior cortex				

Table 1

Socio-demographic profile and mechanism of injury

Variable		Frequency (N=51)	(%)
Gender	Female	15	29.4
	Male	36	70.6
Age in years (Mean ± SD)	39.7 ± 12.4		
	FFH	2	3.9
	Missile injury	2	3.9
Mechanism of injury	PedMCRTA	3	5.9
	PedMVRTA	5	9.8
	PMCRTA	29	56.9
	PMVRTA	4	7.8
	PTRTA	6	11.8

PedMCRTA: Pedestrian Motorcycle Road Traffic Accident; PedMVRTA: Pedestrian Motor Vehicular Road Traffic Accident; PMCRTA: Passenger Motorcycle Road Traffic Accident; PMVRTA: Passenger Motor Vehicular Road Traffic Accident; PTRTA: Passenger Tricycle Road Traffic Accident

Table 2

Gustilo-Anderson class, non-union, infection with positive cultures and re-fixation

Variable		Frequency (N=51)	(%)
Gustilo-Anderson Class	IIIA	22	43.1
	IIIB	29	56.9
Non-union	Yes	9	17.6
	No	42	82.4
Infection with polymicrobes	Yes	20	39.2
	No	31	60.8
New Infection after initial positive cultures	Yes	4	20.0
	No	16	80.0
Re-fixation	Yes	8	15.7
	No	43	84.3

Table 3

Distribution of presentation-intervention interval, duration on external fixator, time to partial weight bearing, time to full weight bearing and union

Variable	Mean	Standard Deviation	Median
Presentation-intervention interval (hours)	41.5	3.3	41.0
Duration on external-fixator (days)	108.4	20.2	114.0
Time to partial weight bearing in (weeks)	14.9	2.4	14.0
Time to full weight bearing (weeks)	21.8	2.8	21.5
Union (weeks)	32.9	6.2	30.0

Table 4

Associations between Gustilo-Anderson Class, duration on external-fixator, time to weight bearing and union

Variables	Gustilo-Anderson Class	Mean	S.D.	T-test value	P-value
Duration on external-fixator (days)	IIIA	87.0	2.2	- 20.019	< 0.001
	IIIB	124.7	9.8		
Time to partial weight bearing (weeks)	IIIA	14.2	1.8	- 2.132	0.039
	IIIB	15.6	2.6		
Time to full weight bearing (weeks)	IIIA	20.6	1.9	- 2.873	0.006
	IIIB	22.9	3.1		
Union time (weeks)	IIIA	29.9	4.1	- 3.447	0.001
	IIIB	35.6	6.5		

DISCUSION

We note that majority of fractures managed through this technique of application of external fixator and conversion to cast at RUST 4 achieved union. With the exception of nine fractures that failed to heal and needed additional surgeries to aid healing, most fractures went on to heal albeit we noted a lengthy time to radiologic healing (Table 4). Using this technique of application of external fixator and conversion to cast we observed a mean healing time of 32.9 (SD 6.2) weeks (Table 3). Naique and colleagues (18) in a study observed a mean time to union of 29 (SD 5.1) weeks. Their study alluded to a prompt intervention in a fraction of their patients who showed delayed callus formation or in whom implant selection was wrong, skeletal stabilization was inadequate or those with infection at presentation. Our patients did not have any form of added surgical intervention to prevent non-union or speed up healing except for those whose fractures out rightly failed to unite and they were noted as cases of non-union. In a larger context, this may mean that debridement and external fixation followed by cast could be a sufficient surgical technique for open fractures. In the absence of non-union, it tends to reduce the number of procedures patients need to go through and by extension lowers the cost burden especially in climes with poor health insurance coverage and those in which healthcare is paid out-of-pocket by patients. One area that can be explored in future research is determining if using a different RUST timetable would achieve the same or a different outcome.

We also observed that at a mean presentation-intervention interval of a little under 48 hours, the pin tract infection rate did not far exceed widely published rates (Table 3). Indeed most organisms cultured at swabs taken before initial debridement were predominantly the same seen at weekly positive cultures (Table 2). For patients with surgical site infection/pin tract infections, we did not observe a significant escalation in infection rates beyond organisms cultured on presentation. Naique *et al.* (18) in another study did not observe persistently infected fractures. In comparison to their study, our infection rate was much higher than theirs possibly because we did not dichotomize between superficial and deep infections but simply included all cases of infections. Their study took into cognizance only deep infections. Furthermore, all our initial debridement were done outside the golden hours. While we feel that this too may account for our higher infection rates, Harley *et al.* (19) in their study found that time to treatment was not a significant predictor of infection. In our study on the contrary, we believe that our lengthy presentation-intervention time may have contributed to infection rates seen since most organisms cultured on presentation persisted. It is plausible to believe that an early debridement may have reduced the contamination and by extension the infection rates.

On the overall, this finding from this study could mean that even beyond the golden hours of debridement there could still be a permissible time frame within which risk of infection is still minimal (Table 2). This is particularly useful for high volume centres where theatre waiting times even for urgent procedures could stretch beyond what is permissible as per available literature evidence. This is handy for theatres in developing countries where poor theatre organizational structure produces bottle necks in getting cases done.

The Radiologic Union Scale for Tibial (RUST) fractures can be a very useful guide for safe graduation of patients with tibia fractures across the stages of treatment and rehabilitation. Leow, *et al.* (20) demonstrated in their study that guided by RUST, tibia fractures had a mean healing time of 18.7 weeks. Their study consisted of cases of tibia fractures managed by intramedullary nailing in which healing was defined as a RUST score of 10 and above. The RUST in this study was not necessarily used to determine healing but to safely graduate patients across the phases of rehabilitation and weight bearing-RUST 6 for partial weight bearing, RUST 11 for cast removal and RUST 12 for full weight bearing. We believe that the predictive ability of the RUST can be explored by clinicians not just in the determination of healing but in the guiding the phases of rehabilitation in tibia fractures. The RUST though by virtue of nomenclature may be restricted to tibia fractures but its principle could possibly be extrapolated to other long bone fractures. The versatility of the RUST is such that the timetable for mobilization used in this study can be compared against other timetables as an avenue for future research.

The clinical applicability of the use of external fixation and subsequent conversion to cast application as demonstrated in this study could be considered as a definitive option in managing open tibia fractures. This can particularly be useful in climes where the cost of multiple surgeries may be over bearing on patients due to inadequate insurance coverage- this option can be considered. Furthermore, the absence of on hand plastic surgeons in some centres to achieve raising of flaps and optimum soft tissue management to permit subsequent intramedullary nail insertion can also make for the consideration of this option of management as a reasonable alternative. In addition, the absence of supporting theatre ancillaries such as image intensifiers in certain developing climes to permit for intramedullary nail insertion creates another scenario in which other options such as this could be considered.

One of the draw backs of this study is the small sample size and the single centre nature of the study design. Findings from this study may be difficult to extrapolate to the general orthopaedic practice. A larger scale multicentre study would have more far reaching derivations.

CONCLUSION

Management of open tibia fractures with external fixator and conversion to cast immobilization results in good healing. Presentation-intervention interval of close to 48 hours does not significantly affect pin tract infection rates. RUST is a useful guide for safe graduation of patients with tibia fractures across the stages of treatment rehabilitation.

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REFERENCES

1. Hauser, C.J., Adams, C.A. Jr., and Eachempati, S.R. Council of the Surgical Infection Society. Surgical Infection Society guideline: prophylactic antibiotic use in open fractures: an evidence-based guideline. *Surg Infect* (Larchmt). 2006; **7**(4):379-405. doi: 10.1089/sur.2006.7.379. PMID: 16978082.
2. Court-Brown, C.M., Mc Queen, M.M, and Quaba, A.A.(1996). Management of open fractures. St. Louis; London: Mosby; M Dunitz.
3. Court Brown, C.M., Rimmer, S., Prakash, U. and Mc Queen, M.M. The epidemiology of open long bone fractures. *Injury*. 1998; **29**(7):529-534.
4. Court-Brown, C.M., Bugler, K.E., Clement, N.D., Duckworth, A.D. and McQueen, M.M. The epidemiology of open fractures in adults. A 15-year review. *Injury*. 2012; **43**(6):891-897. doi: 10.1016/j.injury.2011.12.007. Epub 2011 Dec 27. PMID: 22204774.
5. Poletti, F.L., Macmull, S., Mushtaq, N. and Mobasheri, R. Current concepts and principles in open tibial fractures - Part II Management. *MOJ Orthop Rheumatol*. 2017; **8**(2): 00305. DOI: 10.15406/mojor.2017.08.00305
6. Patil, M.Y., Gupta, S.M., Kurupati, S.K., Agarwal, S. and Chandarana, V. Definitive management of open tibia fractures using limb reconstruction system. *J Clin Diagn Res*. 2016; **10**(7):RC01-4. doi: 10.7860/JCDR/2016/17978.8124. Epub 2016 Jul 1. PMID: 27630916; PMCID: PMC5020215.
7. Hao, Z.C., Xia, Y., Xia, D.M., Zhang, Y.T. and Xu, S.G. Treatment of open tibial diaphyseal fractures by external fixation combined with limited internal fixation versus simple external fixation: a retrospective cohort study. *BMC Musculoskelet Disord*. 2019; **20**(1):311. doi: 10.1186/s12891-019-2679-9. PMID: 31266474; PMCID: PMC6607594.
8. Cross, W.W. 3rd and Swiontkowski, M.F. Treatment principles in the management of open fractures. *Indian J Orthop*. 2008; **4**2(4):377-386. doi: 10.4103/0019-5413.43373. PMID: 19753224; PMCID: PMC2740354.
9. Hohmann, E., Birkholtz, F., Glatt, V. and Tetsworth, K. The "Road to Union" protocol for the reconstruction of isolated complex high-energy tibial trauma. *Injury*. 2017; **48**(6):1211-16. doi: 10.1016/j.injury.2017.03.018. Epub 2017 Mar 18. PMID: 28351547.
10. Foote, C.J., Guyatt, G.H., Vignesh, K.N., Mundi, R., Chaudhry, H., Heels-Ansdell, D., *et al*. Which surgical treatment for open tibial shaft fractures results in the fewest reoperations? A Network Meta-analysis. *Clin Orthop Relat Res*. 2015; **473**(7):2179-92. doi: 10.1007/s11999-015-4224-y. Epub 2015 Feb 28. PMID: 25724836; PMCID: PMC4457757.
11. Hofmann, A., Dietz, S.O., Pairon, P. and Rommens, P.M. The role of intramedullary nailing in treatment of open fractures. *Eur J*

Trauma Emerg Surg. 2015; **41**(1):39-47. doi: 10.1007/s00068-014-0485-5. Epub 2014 Dec 24. PMID: 26038164.

12. Li, Y., Jiang, X., Guo, Q., Zhu, L., Ye, T. and Chen, A. Treatment of distal tibial shaft fractures by three different surgical methods: a randomized, prospective study. *Int Orthop*. 2014; **38**(6):1261-67. doi: 10.1007/s00264-014-2294-1. Epub 2014 Feb 19. PMID: 24549966; PMCID: PMC4037508.
13. Bach, A.W. and Hansen, S.T. Jr. Plates versus external fixation in severe open tibial shaft fractures. A randomized trial. *Clin Orthop Relat Res*. 1989; **241**:89-94. PMID: 2924483.
14. Bosse, M.J., Staeheli, J.W. and Reinert, C.M. Treatment of unstable tibial diaphyseal fractures with minimal internal and external fixation. *J Orthop Trauma*. 1989; **3**(3):223-331. doi: 10.1097/00005131-198909000-00007. PMID: 2809823.
15. Spiegel, P.G. and VanderSchilden, J.L. Minimal internal and external fixation in the treatment of open tibial fractures. *Clin Orthop Relat Res*. 1983; **178**:96-102. PMID: 6883873.
16. Tu, Y.K., Lin, C.H., Su, J.I., Hsu, D.T. and Chen, R.J. Unreamed interlocking nail versus external fixator for open type III tibia fractures. *J Trauma*. 1995; **39**:361-367.
17. Giovannini, F., de Palma, L., Panfighi, A. and Marinelli, M. Intramedullary nailing versus external fixation in Gustilo type III open tibial shaft fractures: a meta-analysis of randomised controlled trials. *Strategies Trauma Limb Reconstr*. 2016; **11**(1):1-4. doi: 10.1007/s11751-016-0245-7. Epub 2016 Feb 26. PMID: 26920713; PMCID: PMC4814385.
18. Naique, S.B., Pearse, M. and Nanchahal, J. Management of severe open tibial fractures. *J Bone Joint Surg*. 2006; **88-B**(3). Doi.org/10.1302/0301-620x.88B3.
19. Harley, B.J., Beaupre, L.A., Jones, C.A., Dulai, S.K. and Weber, D.W. The effect of time to definitive treatment on the rate of nonunion and infection in open fractures. *J Orthop Trauma*. 2002; **16**(7):484-490. doi: 10.1097/00005131-200208000-00006. PMID: 12172278.
20. Leow, J.M., Clement, N.D. and Simpson, A.H.W.R. Application of the radiographic union scale for tibial fractures (RUST): Assessment of healing rate and time of tibial fractures managed with intramedullary nailing. *Orthop Traumatol Surg Res*. 2020; **106**(1):89-93. doi: 10.1016/j.otsr.2019.10.010. Epub 2019 Nov 27. PMID: 31786133.