Original Article

Prevention of Equinus Deformity after External Fixation for Open Tibia Fractures: A Comparison between Plaster of Paris Backslab and Passive Ankle Physiotherapy

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Abstract

Background: Ankle equinus deformity is a common complication of prolonged external fixator use in tibia fractures with an incidence of 15%–16%. It affects gait and may lead to foot, leg, and back problems. Treatment of equinus deformity increases the cost of treatment of open tibia fractures and increases the time spent off work. Several preventive modalities have been suggested in literature with variable success, but no standard protocol exists. **Objectives:** The aim of this study was to determine the most appropriate method of preventing equinus deformity of the ankle joint during the management of open tibia fractures with unilateral uniplanar external fixators by comparing plaster of paris (POP) backslab application with passive ankle physiotherapy using strips of car tyre inner tubing. **Materials and Methods:** The study was a prospective randomised study involving patients with open tibia fractures who were managed with external fixators at the Korle Bu Teaching Hospital between April 2020 and February 2021. Patients were randomised into two groups; one group had below knee POP backslab and the other group did passive ankle physiotherapy using a strip of car tyre inner tubing. The passive ankle range of motion was measured at the beginning and after 6 weeks using a goniometer. **Results:** Fifty-six participants were recruited with 29 in the POP backslab group and 27 in the ankle physiotherapy group. The median age was 35.0 years. Male-to-female ratio was 4.6:1. Motor vehicle crash contributed to over 90% with 42.9% being motorbike riders. Initial and final mean ankle measurements for the POP backslab group were 6.79° and 10.14° for dorsiflexion and 29.93° and 34.52° for plantarflexion, respectively. The ankle physiotherapy group had initial and final dorsiflexion of 7.19° and 12.85° and plantarflexion of 30.44° and 34.52°, respectively. The ankle physiotherapy group had a better range of motion (47.37°) than the POP group (40.66°) with a *P* value of 0.008. One participant (3.7%) from the ankle physiotherapy group had equinus deformity compared with seven (24%) from the POP backslab group, a difference which gives a *P* value of 0.029. **Conclusions:** Passive ankle physiotherapy with car tyre inner tube is a better and cheaper modality of preventing ankle equinus deformity and maintaining ankle range of motion.

Keywords: *Car tyre inner tube, equinus deformity prevention, external fixator, POP backslab*

Introduction

External fixation of open fractures is minimally invasive and allows for quick stabilisation of fractures and simultaneous treatment of bone and soft tissue damages.[1] Its use is, however, associated with complications such as pin tract infections, injury to neurovascular structures, stress fractures at pin sites, loss of ankle range of motion and equinus deformity of the ankle joint. Equinus deformity which refers to loss of ankle joint dorsiflexion is a well-documented complication of tibia external fixation.[2,3] Taylor and Allum[2] reported a mean loss of 8° plantar flexion and 12° dorsiflexion after tibia external fixation.

Most authors define equinus as less than 10° of ankle joint dorsiflexion from the plantigrade position (90° between foot and tibia) with the subtalar joint in neutral position.[3-7] This definition is appropriate because a minimum of 10° of ankle dorsiflexion is required for the foot to clear the ground in the swing phase of the gait cycle.[8]

Incidence of equinus deformity is reported to be as high as 15%–16% in open fractures managed with external fixators.[9,10] Patients develop compensatory mechanisms which

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eventually lead to other foot, leg, and back problems.[1,11] It is said that "the worst foot in the world is the one with a fully compensated equinus deformity."[12]

Treatment of ankle equinus deformity has ranged from serial casting, Achilles tendon lengthening, open soft tissue release and osteotomies in severe cases.[13] This extra treatment increases the patients cost and the amount of time spent off work to seek treatment.[14]

Measures adopted to prevent equinus deformity during tibia external fixation include the use of orthofix unilateral frames and ring fixators with metatarsal pins connected to the fixator.[15] Simpler methods using elastic tubings and shoelaces have been reported.[16,17]

Materials and Methods

This is a prospective randomised study involving adult patients who presented to the Orthopaedic and Trauma Unit of the Korle Bu Teaching Hospital in Ghana, with open tibia fractures. The study duration was between April 2020 and February 2021. Ethical clearance was obtained from the Scientific and Technical Committee/ Ethical Review Board of Korle Bu Teaching Hospital.

The study population included patients 18 years and above with open tibia fractures who were managed with external fixation. Patients with pre-existing ankle deformities, other injuries on the ipsilateral lower limb, inability to cooperate with physiotherapy instructions due to head injury/mentally challenged, ankle-spanning external fixators and Gustilo 3C open tibia fractures were excluded from the study.

The patients were randomised into two groups (Group A and Group B) by picking from an envelope with cards labelled A or B after securing informed consent. All patients had uniplanar external fixators mounted after wound debridement. On post-operative day 2, ankle range of motion measurements was taken using a plastic goniometer.

On post-operative day 2, group A had below knee plaster of paris backslab applied using 8 double rolls of 8" POP and with the foot in plantigrade position as shown in Figure 1.

Patients assigned to group B were given a strip of car tyre inner tube obtained from Vulcanizers and Automechanics, cut to a width of 5 cm and washed with soap and water and air-dried. They were taught to do ankle range of motion exercises by wrapping the strip of inner tube around the foot at the level of the metatarsal heads and pulling on it (stretching) twice daily [Figure 2].

Each stretching session comprised 10 pulls with each achieving maximal dorsiflexion as pain will allow and maintained for 30 s followed by a 30-s resting interval between pulls. The rubber tubing was wrapped around the external fixator to keep the ankle in plantigrade position at night [Figure 3].

Figure 1: Patient with below knee POP backslab applied after external fixation

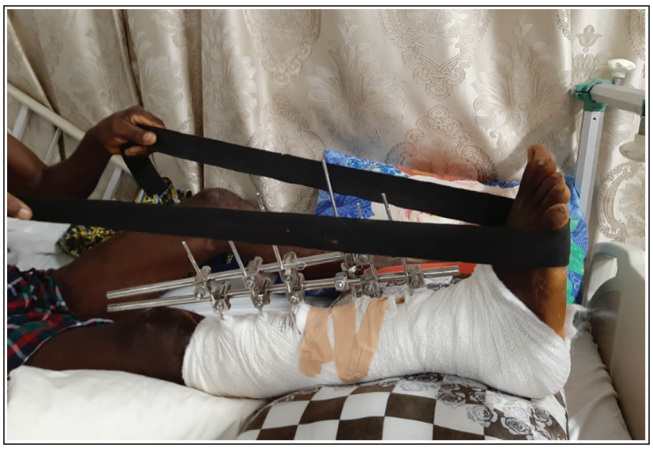

Figure 2: Passive ankle physiotherapy using a strip of car tyre inner tube (stretching phase)

Figure 3: Night splinting with strip of car tyre inner tube tied to external fixator

The passive ankle range of motion was measured after 6 weeks. Data were entered into SPSS version 25 for storage and analysis. Quantitative variables were summarised as means and qualitative data as frequencies and percentages. The Chi-square test was used to check for association between variables and independent *t* test to compare differences between means.

Results

Fifty-six participants were recruited into the study with 29 in the POP backslab group and 27 in the ankle physiotherapy group.

There were 46 males and 10 females as shown in Figure 4 with a male-to-female ratio of 4.6:1. The youngest participant was 18 years and the oldest was 70 years. The median age was 35.0 with the majority of patients in the 21–39- and 31–40-year groups [Figure 5]. There was no statistically significant difference in the age and sex distribution of patients between the two groups (*P* value of 0.333 and 0.901, respectively).

Over 90% of the participants got injured through a motor vehicle crash either as pedestrians or motorbike riders with 42.9% being motorbike riders [Figure 6].

The right and left legs were equally affected (29 and 27, respectively). Middle third fractures (30 [53.6%]) were predominant, followed by distal third and proximal third (20 [35.7%] and 6 [10.7%], respectively). Twenty-two (39.3%) participants had transverse fractures, nine (16.0%) had oblique fractures, four (7.1%) were spiral fractures, nine (16.1%) were segmental fractures, and twelve (21.4%) were comminuted fractures.

Gustilo IIIB (57.1%) fractures were predominant followed by Gustilo 3A (38.6%). There was only one case (1.8%) of Gustilo 2 fracture [Figure 7].

As Tables 1 and 2 show, initial and final mean ankle dorsiflexion for the POP backslab group was 6.79° and 10.14°, respectively. Plantarflexion was 29.93° and 34.52°, respectively. The ankle physiotherapy group had initial and final dorsiflexion of 7.19° and 12.85°, respectively, and plantarflexion of 30.44° and 34.52°, respectively. The difference in the mean ankle range of motion between the two groups (40.66° and 47.37°, respectively) was statistically significant (*P* value of 0.008) with the ankle physiotherapy group having a better range of motion.

One participant (3.7%) from the ankle physiotherapy group had equinus deformity compared with seven (24%) from the POP backslab group [Table 3]. This difference was statistically significant (*P* value of 0.029).

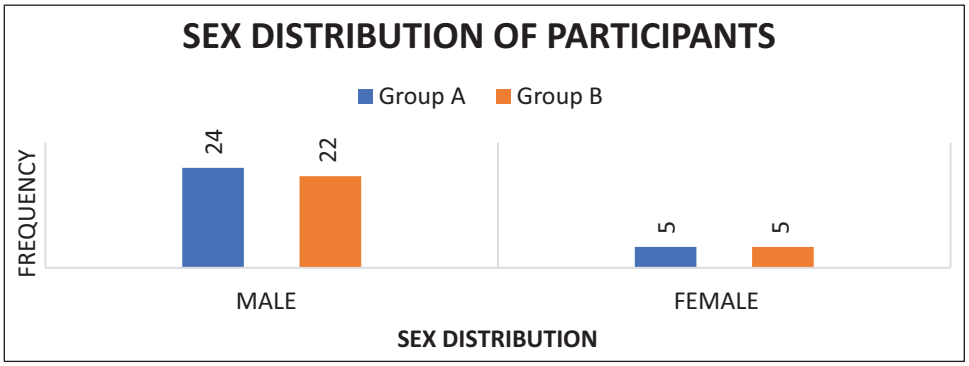

Figure 4: Sex distribution of participants

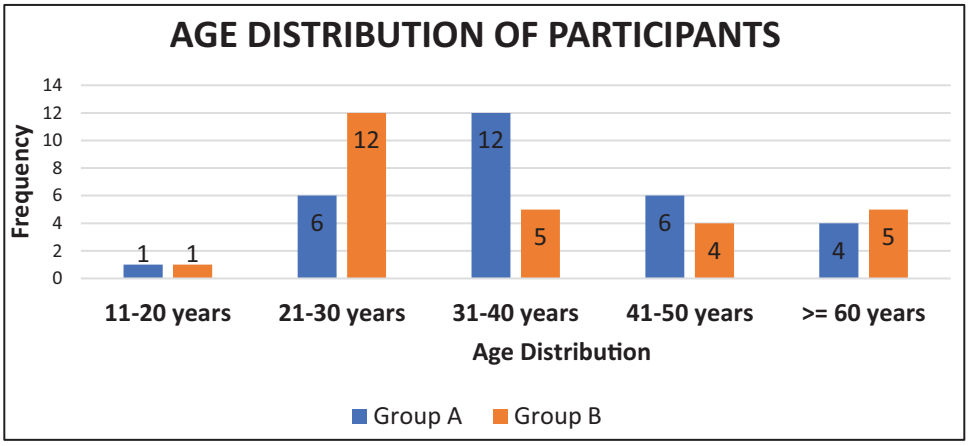

Figure 5: Age distribution of participants

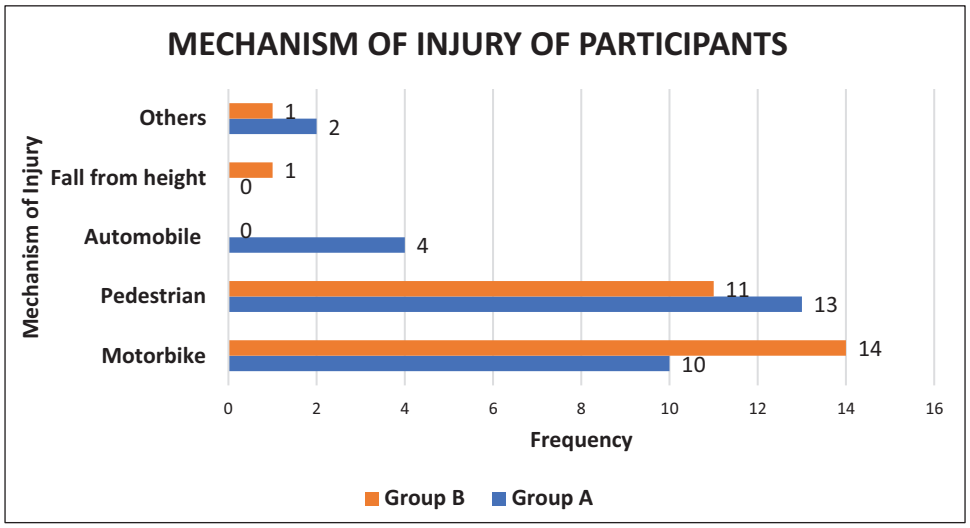

Figure 6: Mechanism of injury

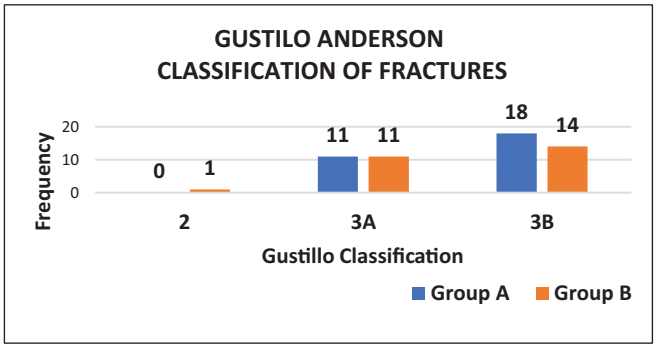

Figure 7: Gustilo Anderson classification of fractures

One participant from the POP group and two from the passive physiotherapy group developed pin tract infections which were managed successfully.

Discussion

The results of the study showed a male-to-female ratio of 4.6:1. The median age was 35 years and the majority of participants were from 21- to 40-year group. This is consistent with other research findings in the subregion. Tolgou *et al*.,[18] Abang *et al*.,[19] Ibeanusi and Ekere,[20] and Kumar *et al*.[21] also reported similar findings in Ghana and Nigeria. This is so because males are more involved in driving and other high-risk activities.[22]

Motor vehicular accidents (MVA) were the mechanism of injury in over 90% of the participants. Motorbike riders constituted 42.9% of the participants with pedestrians who were knocked by either motorbikes or vehicles also forming 42.9% of the participants. Tolgou *et al*.[18] and Ibeanusi and Ekere[20] also reported a similar statistic with 87.4% and 91% of their participants, respectively, sustaining their injury from MVA and with over 50% motorbike involvement. The high incidence of motorbike-related accidents gives credence to the worrying trend of motorbikes increasingly becoming the major source of public transport hence cause of Road traffic injuries.[23] It also brings to fore the safety issues related to the use of motorbikes as public transport.

The right and left tibia were equally affected in my study (*P* value of 0.599). This is consistent with other findings that have no agreement on the predominant limb affected.[19,24]

Middle third fractures were predominant (53.6%) with proximal third being the least (10.7%). This is similar to the findings of Kumar *et al*.[21] who reported 70.3% middle third fractures followed by lower third (24.3%) and upper third fractures (5.4%). Abang *et al*.,[19] however, reported more distal third fractures.

Majority (39.3%) of the fractures managed were transverse fractures with the rest almost equally distributed among the other fracture patterns. Abang *et al*.[19] on the contrary reported more comminuted fractures with transverse fractures being the least. This pattern may be due to the fact that the patients in Calabar, Nigeria were involved in higher energy injuries than those in Accra, Ghana.

Our study found 57.1% type IIIB, 39.2% type IIIA, and 1.8% type II fractures. Type III injuries constituted 98% of participants in this study. This pattern is explained by the fact that intramedullary nailing is currently considered the treatment of choice for Gustilo I and II open tibia fractures[25] and so at the Korle Bu Teaching Hospital, external fixators are used mainly for Gustilo III injuries. Thirty-two (57.1%) had Gustilo IIIB fractures and 22 (39.3%) had Gustilo IIIA fractures and only one (1.8%) had Gustilo 2 fracture. Tolgou *et al*.[18] reported 11% Gustilo type I fractures, 36% type II fractures, 21% type IIIA fractures and 32% type IIIB fractures. Kumar *et al*.[21] reported 20 (54.1%) type II injuries, 9 (24.3%) type IIIA and 8 (21.6%) type III B injuries in 37 participants. Abang *et al*.[19] also reported 15%, 50%, and 35% for Gustilo II, IIIA, and IIIB, respectively. Tolgou's study considered all

Table 1: Mean initial passive range of motion

Variable	Group A (n = 29)	Group B (n = 27)	t	P value
	Mean (SD)	Mean (SD)		
Dorsiflexion angle	6.79 (9.43)	7.19 (5.90)	−0.185	0.854
Plantarflexion angle	29.93 (8.21)	30.44 (8.96)	−0.224	0.824

Table 2: Mean passive range of motion 6 weeks

Variable	Group A (n = 29)	Group B (n = 27)	t	P value
	Mean (SD)	Mean (SD)		
Dorsiflexion angle	10.14 (8.09)	12.85 (3.73)	−1.585	0.119
Plantarflexion angle	30.96 (5.83)	34.52 (6.05)	−1.594	0.117

Table 3: Number of participants with equinus deformity (dorsiflexion <10°) at 6 weeks

Equinus deformity	Group A (%)	Group B (%)	Total	χ^2 value	P value
Yes	7 (24.1)	1 (3.7)	8 (21.8)	4.768	0.029
No	22 (60.7)	26 (96.3)	48 (78.2)		
Total	29 (100.0)	27 (100.0)	56 (100.0)		

open tibia fractures irrespective of management, but this study included only those managed with external fixation hence the high proportion of Gustilo III injuries.

The initial range of motion obtained from the study (6.79° dorsiflexion and 29.93° plantarflexion for group A and 7.19° dorsiflexion and 30.44° plantarflexion for group B) was less than the normal ankle range of motion of an uninjured limb (20° dorsiflexion and 50° plantarflexion).[26] This amounts to a mean loss of about 13° dorsiflexion and 20° plantarflexion. This reduction may be attributed to pain and patient anxiety at the time of measurement (48 h after surgery). When left without any intervention, this functional loss of range of motion may progress to structural stiffness which may need surgical and non-surgical interventions to correct.

At 6 weeks, average passive dorsiflexion for the POP backslab group had increased by 5° and that of the ankle physiotherapy group had increased by 6° to 12.85°. Passive ankle physiotherapy using car tyre inner tube, therefore, leads to a statistically insignificant improvement in dorsiflexion compared to POP backslab (P value of 0.119). A similar statistically insignificant improvement was observed for mean plantarflexion between the two groups (P value of 0.117).

The group managed with passive ankle physiotherapy with car tyre inner tube had an overall higher and statistically significant mean ankle range of motion of 47.37° compared to the group managed with POP backslab (40.66°). It can therefore be inferred from the findings that even though ankle physiotherapy with car tyre inner tube does not fully restore the ankle range of motion fully at 6 weeks, it maintains range of motion better than POP backslab.

The higher range of motion of the ankle physiotherapy group compared to the POP backslab group is because whereas the POP backslab keeps the ankle joint statically splinted, the ankle physiotherapy allows for both active and passive movement, which helps maintain muscle tone and so causes less stiffness.

Seven (24.1%) of the respondents who had POP backslab had equinus deformity whereas only one (3.7%) from the passive physiotherapy group had equinus deformity at six weeks. This difference was statistically significant (χ^2 of 4.768, P value of 0.029). Passive ankle physiotherapy with car tyre inner tube can, therefore, be said to be more effective at preventing equinus deformity during external fixation.

Both methods had 100% of participants with plantigrade feet after 6 weeks meaning they were equally effective at keeping the foot plantigrade which is the minimum required for the patient to stand.

No study was found that compared these two methods of preventing ankle equinus deformity in external fixation. Jain *et al.*[16] used car tyre inner tube for equinus prevention and reported that none of their 22 patients had equinus deformity at 6 weeks. This 100% result was slightly better than the 96.3% from this study. Their study, however, did not specify what their definition of equinus was. This, therefore, makes it difficult to do an objective comparison. Both studies, however, achieved good results.

Using incremental cost analysis, the total cost involved in collecting the rubber tyre inner tubes and preparation amounts to an average of ¢25.70 ($4.40) for each patient. The POP backslab, however, costs an average ¢144.80 ($25.00) per person. From analysis above, it can be concluded that the car tyre inner tube is a cheaper means of prevention of equinus deformity.

Three patients developed pin tract infections which were managed by improved pin site care and antibiotics. Two were in the passive physiotherapy arm with one in the POP

arm. Even though there was an attempt at disinfection of the inner tube, the soap and water could not sterilise it, hence the tube is a potential source of infection. There were no skin reactions to either the POP or car tyre inner tube. The difference in the complication rate was not statistically significant (*P* value of 0.511).

Eleven patients (37.9%) from the POP group had either a broken or wet POP which had to be changed. This breakage/wetness of the POP backslab which reduces the ability of the backslab to maintain the foot in plantigrade position may have contributed to the higher incidence of equinus in the POP Backslab group. This relatively high risk of failure makes the POP backslab a less suitable method of equinus prevention. The high incidence of breakage could also be because the POP backslab was less stiff. The rate may possibly have been lower if more rows of POP were used.

Conclusion

From the findings above it can be concluded that passive ankle physiotherapy with car tyre inner tube is a more effective and cheaper method of preventing equinus deformity of the ankle joint during tibia external fixation than POP backslab.

Limitations

A sample size of 56 is relatively small and a larger study may be needed to apply the results to the larger population. Even though the participants who had ankle physiotherapy agreed and committed to comply with the physiotherapy sessions, it was difficult to measure compliance.

Recommendations

Based on the findings from this study we recommend the use of strips of car tyre inner tube for the prevention of equinus deformity in patients who are being managed with tibia external fixation and can comply with physiotherapy instructions. A larger multicentre study is recommended to validate the effectiveness of passive ankle physiotherapy during and after external fixation of open tibia fractures.

Declaration of patient Consent

The authors certify that they have obtained all appropriate patient consent forms. In the form the patient(s) has/have given his/her/their consent for his/her/their images and other clinical information to be reported in the journal. The patients understand that their names and initials will not be published and due efforts will be made to conceal their identity, but anonymity cannot be guaranteed.

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Conflicts of interest

There are no conflicts of interest.

References

1. Qiu S, Liu J, Liu C. Effects of external fixation technique on hospitalization time, fracture healing time and complication rate of pediatric fracture. Int J Clin Exp Med 2017;10:12179-85.
2. Taylor GJ, Allum RL. Ankle motion after external fixation of tibial fractures. J R Soc Med 1988;81:19-21.
3. Charles J, Scutter SD, Buckley J. Static ankle joint equinus: Toward a standard definition and diagnosis. J Am Podiatr Med Assoc 2010;100:195-203.
4. Meszaros A, Caudell G. The surgical management of equinus in the adult acquired flatfoot. Clin Podiatr Med Surg 2007;24:667-85.
5. Gatt A, Chockalingam N. Assessment of ankle joint dorsiflexion: An overview. Rev Int Cienc Podol 2012;6:25-9.
6. Dananberg H, Shearstone J, Guillano M. Manipulation method for the treatment of ankle equinus. J Am Podiatr Med Assoc 2000;90:385-9.
7. Maurer BT, Siegler S, Hillstrom HJ, Selby-Silverstein L, Farrett WD, Downey MS. Quantitative identification of ankle equinus with applications for treatment assessment. Gait Posture 1995;3:19-28.
8. Weir J, Chockalingam N. Ankle joint dorsiflexion: Assessment of true values necessary for normal gait. Int J Ther Rehabil 2007;14:76-82.
9. Khalid HS, Khan AS, Afsar SS. External fixator in the treatment of open fractures of tibia. J Postgrad Med Inst 2011;25:62-7.
10. Carballedo J, Schmauch M, Langa J, Miralles RC. Type III-B open tibial fractures in Mozambique. Int Orthop 1996;20:300-4.
11. Barrett SL. Understanding and managing equinus deformities. Podiatry Today 2011;24:58-66.
12. DeHeer PA. Equinus and lengthening techniques. Clin Podiatr Med Surg 2017;34:207-27.
13. Stuart MJ, Dahners LE. A technique for correction of equinus contracture using a wire fixator and elastic tension. J Orthop Trauma 2006;20:138-42.
14. Amis J. The split-second effect: The mechanism of how equinus can damage the human foot and ankle. Front Surg 2016;3:38.
15. Yoshino A, Takao M, Innami K, Matsushita T. Equinus deformity during tibial lengthening with ankle orthoses for equalization of leg-length discrepancies. J Orthop Sci 2011;16:756-9.
16. Jain V, Agrawal M, Dhal A. Catapult splint: A foot dorsiflexion assist splint. Foot Ankle Surg 2011;17:312-4.
17. O'Neill BJ, Burke NG, Moore DP, Kelly PM. A standard shoelace prevents equinus posturing of the ankle during circular external fixation of the tibia. Foot Ankle Surg 2015;21:67-9.
18. Tolgou Y, Ofori A, Holdbrook-Smith H, Wegdam H. Treatment outcome of open tibial shaft fractures in a teaching hospital in Ghana. Postgrad Med J Ghana 2017;6:47-53.
19. Abang IE, Asuquo JE, Anisi CO, Mpama EA, Onuba OO, Udosen AM, *et al*. Early outcome of treatment of open tibia shaft fractures using external fixators in resource-poor setting. Recent Adv Biol Med 2018;4:1-9.
20. Ibeanusi S, Ekere A. Epidemiology of open tibial fractures in a teaching hospital. Port Harcourt Med J 2007;1:156-60.
21. Kumar R, Sujai S, Chethan, Nanjundappa HC, Swamy S. Results of open fractures of tibia treated by external fixator as primary and definitive procedure. Int J Orthop Sci 2017;3:179-81.
22. El-Menyar A, El-Hennawy H, Al-Thani H, Asim M, Abdelrahman H, Zarour A, *et al*. Traumatic injury among females: Does gender matter? J Trauma Manag Outcomes 2014;8:8.

23. Cavalcanti AL, Lucena B, Rodrigues IS, Silva AL, Lima TT, Xavier AFC. Motorcycle accidents: Morbidity and associated factors in a city of northeast of Brazil. Tanzan J Health Res 2014;15:209-15.
24. Onuminya JE. Study of the use of external fixation in the treatment of tibial fractures 1995:35-7.
25. Manjra M, Basson T, Du Preez G, Du Toit J, Ferreira N. Current concepts in the management of open tibia fractures. SA Orthop J 2019;18:52-62.
26. Abu El Kasem ST, Aly SM, Kamel EM, Hussein HM. Normal active range of motion of lower extremity joints of the healthy young adults in Cairo, Egypt. Bull Fac Phys Ther 2020;25:1-7.