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Accuracy of point of care ultrasound in the diagnosis of long bone fractures in the emergency department

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Abstract

Introduction: Long bone fractures account for a significant portion of injuries in the emergency department (ED). This study aimed to determine the accuracy of point of care ultrasound (POCUS) compared to x-ray in the diagnosis of long bone fractures in the ED.

Method: This cross-sectional study assessed 147 patients presenting to the ED of Patan Academy of Health Sciences (PAHS), with suspected long bone fractures, from Oct 2021 through Jun 2022. In all patients, POCUS examination was done by emergency fellows and then standard plain x-ray was performed. Data were analyzed by SPSS 28.0 to determine sensitivity and specificity.

Result: A total of 147 patients were included in the study. Compared with x-ray, sensitivity, specificity, PPV and NPV of POCUS in determining fractures was found to be 86%, 98.96%, 97.72% and 93.2%, respectively. Based on bone injured, the highest sensitivity and specificity were obtained with forearm fractures, which was equal to 97.22% and 100%, respectively. Based on age categorization, the highest sensitivity (100%) and specificity (100%) were obtained in pediatric age group i.e. up to 16 years.

Conclusion: This study demonstrated that POCUS has high sensitivity and specificity in the diagnosis of long bone fractures, compared to x-ray.

Keyword: emergency department, long bone fracture, point of care ultrasound

Introduction

Globally the number of fractures are increasing substantially.¹ Fracture accounts for a significant portion of injuries in countries like Nepal.² Long bone fractures are most often caused by traumatic events such as road traffic accidents, fall injuries and assaults.³ Such injuries first come to Emergency department where fractures are need to be diagnose early.

The diagnosis of fractures is traditionally done through plain radiography, which requires time and has a risk of ionizing radiation. Ultrasonography has become an inseparable component of emergency department services in a wide range of diseases, which in turn can result in a decrease in the time needed for diagnosis and treatment.⁴ A point of care ultrasound (POCUS) examination has shown good test characteristics for the diagnosis of long bone fractures.⁵⁻⁷ As it can be performed at the bedside, it reduces diagnostic delays and time to initiation of management. Additional advantages of point of care ultrasound (POCUS) include its simplicity, portability, repeatability and its lack of ionizing radiation. Studies have emphasized that POCUS can be used not only for diagnosing fractures but also for joint effusions, soft tissue injuries and various musculoskeletal pathologies.⁸⁻⁹ Use of ultrasound and the service it provides can be reached in all district of Nepal.¹⁰

This study aims to determine the accuracy, sensitivity and specificity of point of care ultrasound to diagnose long bone fractures in the Emergency Department.

Method

This was a prospective cross-sectional study conducted at Emergency department of Patan Academy of health Sciences (PAHS). After obtaining the ethical approval from Institutional Review Committee of PAHS (Ref: std 2110291575). Data was collected from October 2021 through June 2022.

The general objective of the study was to find the sensitivity of POCUS to diagnose long bone fractures in emergency department of PAHS. The specific objectives were to evaluate the sensitivity and specificity of ultrasonography in diagnosing long bone fractures. The inclusion criteria were patients presenting to the emergency department with extremities injuries. Patients with open fractures, patients with joint injuries and patients not willing to enrol in the study were excluded.

The sample size was calculated 147 using the formula based on the sensitivity.

The study was commenced after obtaining the approval from IRC-PAHS. consent was taken from patients. Clinical examination of the patient was done. Then the point of care ultrasonographic examination of injured long bone was performed by me and fellow faculties with 7.5MHZ linear probe of the standard ultrasound device (Sonosite Turbo M).¹² Long bone was evaluated on anterior, posterior, medial, lateral surfaces and from the proximal to the distal joint in both longitudinal and transverse planes and seen for the discontinuity of cortex of the bone, periosteal elevation and effusion. The investigators documents (ultrasonographic) interpretation was done prior to radiography being performed.

The data was recorded in Microsoft excel and analysis was done using SPSS 28.0.

Sensitivity and specificity of point of care ultrasonography in the diagnosis of long bone fracture was calculated using the formula: Sensitivity = TP/(TP+FN)

and Specificity = TN/(TN+FP). Also, a ROC curve analysis was done in SPSS 28.0 to determine the overall diagnostic accuracy of point of care ultrasonography in the diagnosis of long bone fractures.

Result

A total of 147 patients with suspected upper and lower extremity trauma were evaluated for long bone fracture using point of care ultrasound (POCUS) and x-ray. Of the study patients, the mean age of the patients was 34 y, and 91(62%) were male and 56(38%) were female. In terms of age categorization, patients up to 16 y, 17-30 y, 31-45 and age >45 y were 8(5.4 %), 71(48.3%), 49(33.3%) and 21(14.2%) respectively. Fractures were mostly determined in forearm (48.3%). In terms of injured bone, fracture of humerus, forearm, femur and tibia-fibula were observed in 7(4.7%), 71 (48.3 %), 8(5.4%) and 61(41.5%), respectively, Table 1.

The sensitivity, specificity, PPV and NPV of POCUS in determining the fractures were 86%, 98.96%, 97.72% and 93.2%, respectively, compared to x-ray. Based on bone injured, the highest sensitivity and specificity were obtained with forearm fractures, which was equal to 97.22% and 100%, respectively, Table 3.

The highest sensitivity (94.12%) and specificity (100%) were found in the female patients, Table 4. Based on age categorization, the highest sensitivity (100%) and specificity (100%) were obtained in pediatric age group i.e. up to 16 years, Table 4.

The ROC curve plotted for POCUS showed high sensitivity, Figure 2.

Table 1. Demographic data of patient diagnosed of long bone fractures in the emergency department.

Variables	category	N (%)
Age	Up to 16 years	8(5.4%)
	17-30	71(48.3%)
	31-45	49(33.3%)
	>45	21(14.2%)
Sex	Male	91(62%)
	Female	56(38%)
Bone Type	Femur	8(5.4%)
	Forearm	71(48.3%)
	Humerus	7(4.7%)
	Tibia-Fibula	61(41.5%)

Table 2. Accuracy of care ultrasound in the diagnosis of long bone fractures in the emergency department.

POCUS(point of care ultrasonography)	X-ray Positive	X-ray Negative
Positive	43(TP)	1(FP)
Negative	7(FN)	96(TN)

Table 3. Sensitivity and specificity of care ultrasound in the diagnosis of long bone fractures in the emergency department.

Bone injured	Sensitivity (%)	Specificity (%)	PPV(%)	NPV(%)
POCUS (point of care ultrasonography)-Total	86	98.96	97.72	93.2
POCUS (point of care ultrasonography)- Humerus	50	100	100	83.33
POCUS (point of care ultrasonography)- Forearm	97.22	100	100	97.22
POCUS(point of care ultrasonography)- Femur	0	100	0	62.5
POCUS (point of care ultrasound)- Tibia fibula	77.78	98.07	87.5	96.23

Table 4. Sensitivity and specificity of point of care ultrasound in the diagnosis of long bone fractures in the emergency department according to gender, age category

		Sensitivity (%)	Specificity (%)	PPV (%)	NPV (%)
POCUS (point of care ultrasonography of long bone) - Total	Male	81.81	98.27	96.4	90.4
	Female	94.12	100	100	97.5
	Up to 16 y	100	100	100	100
POCUS (point of care ultrasonography) - Age category	17-30 y	87.7	100	100	91.11
	31-45 y	86.67	100	100	94.44
	>45 y	50	94.7	50	94.74



Figure 1. Longitudinal view of tibial bone POCUS (A), X-ray view of tibial bone (B)

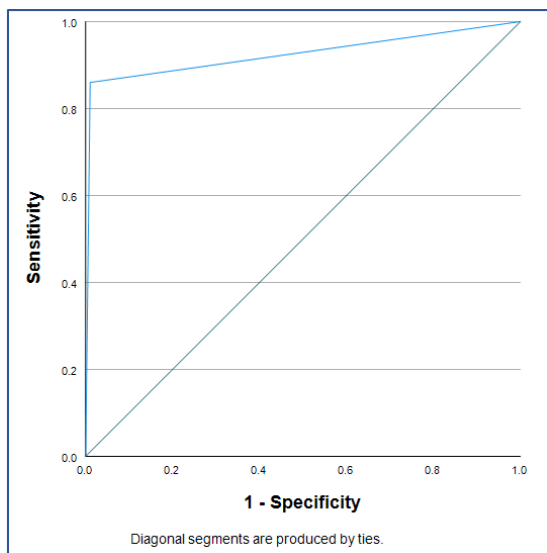


Figure 2. POCUS (point of care ultrasonography) sensitivity ROC curve

Discussion

In our study, the highest sensitivity was seen in forearm bone fracture which was 97.2% with specificity, PPV and NPV of 100%,100%,97.2%, respectively A similar study demonstrated that US compared with

plain radiography has a high accuracy in the diagnosis of upper and lower extremity long bone fractures. In this study, the sensitivity, specificity, PPV and NPV of ultrasound of upper extremity long bones were 95.3%, 87.7%, 87.2% and 96.2%, respectively, while that of lower extremity long bones were 98.6%, 83%, 65.4%, and 87.1%, respectively.⁸ The same study observed, radius fractures to be the most frequent to occur in upper extremities and tibia and fibula fractures to be the most frequent in lower extremities which is similar to our study. Similar results were seen in a study by Brian C. Lau et al. which found the sensitivity of distal radius fracture diagnosis on ultrasound to be 100%.¹³

A study assessed patients suspected of femur bone fracture with ultrasonography and radiography. In this study the sensitivity of ultrasound in diagnosis of proximal femur fracture was 16.6%, that of middle femur fracture was 90% and that of distal femur fracture was 62.5%.¹⁴ In our study, the sensitivity of POCUS for femur bone was 0%. There were total 8 cases of suspected femur

fracture out of which, 3 were false negative and no true positive. Such result could be due to location of the fracture in the femur bone itself.

In our study sensitivity, specificity, PPV, NPV of POCUS of tibia fibula fracture were 77.78%, 98.07%, 87.5%, and 96.23%, respectively. A study, comparing the efficacy of POCUS with radiography in diagnosis of tibia and fibula fracture found ultrasound to be as successful as direct x-ray. The study reported the sensitivity, specificity, PPV and NPV to be 100%, 93%, 88% and 100%, respectively.⁵

In our study, the sensitivity and specificity were highest in age group up to 16 years which was 100% each as they don't have bulky muscle as adults. Many studies have concluded POCUS to be a highly accurate technique enabling the evaluation of long bone fractures in the pediatric population. For example, a prospective, non-randomized study conducted in five medical centers in which 554 examinations were performed with POCUS and X-ray in pediatric patients with trauma found out that Sensitivity of POCUS was 91.67% (95% CI, 76.41–97.82%) for high-skill providers and 71.50 % (95% CI, 64.75–77.43%) for standard-skill providers. Specificity was 88.89% (95% CI, 73.00–96.34%) and 82.91% (95% CI, 77.82–87.06%) for high- and standard-skill providers, respectively. The Cohen κ coefficient showed very good agreement (0.81) for high-skill providers, but moderate agreement (0.54) for standard-skill providers. so with proper training and adequate practicing there would be a good diagnostic accuracy of POCUS in evaluating fracture, with excellent sensitivity and specificity.¹⁵ A study carried out in children aged younger than 15 years to evaluate the utility of POCUS for diagnosing distal forearm fractures showed a sensitivity of 94.4% and specificity of 96.8%. The PPV and NPV were 93.2% and 97.5%, respectively.¹⁶ A prospective diagnostic study for extremity fracture using bedside ultrasound in pediatric trauma conducted at the emergency department of Imam Khomeini Complex Hospital, Tehran, Iran by

Farahmand S et al.). The overall sensitivity, specificity and accuracy of ultrasound in detecting fractures in evaluated pediatrics were 100%, 100% and 100%, respectively. The average time of performing ultrasound in pediatric population is 3.99 ± 0.83 minutes which is statistically significant compared to X-ray, 16.12 ± 4.15 minutes ($P < 0.001$). So bedside ultrasound could be used as an accurate and time saving substitute for x-ray in screening for long bone fractures in pediatric trauma in emergency department.¹⁷ One of the study found sensitivity of ultrasound to be 96.1% and sensitivity to be 97%, in diagnosing non-displaced metaphyseal forearm fractures in children aged 1 to 14 years, compared to x-ray diagnosis.¹⁸ In a similar study performed among children aged 2 to 17 years to a pediatric emergency department showed the agreement between bedside ultrasonography and radiography for fracture identification to be 95.5%. The sensitivity and specificity for fracture identification was 97% and 93%, respectively.¹⁹ So in paediatric population POCUS is useful tool for diagnosing fractures.

In our study, the sensitivity, specificity, PPV and NPV of POCUS were 86%, 98.96%, 97.7% and 93.2%, respectively. Similar findings were observed in a study in which patients with suspected fractures were evaluated by emergency physicians in the emergency department with POCUS and with x-ray. The sensitivity, specificity, PPV and NPV of POCUS, compared to x-ray were 99%, 93%, 93% and 99%, respectively.²⁰ This study also determined the fracture characteristics and found POCUS was able to identify fracture characteristics. Similarly, a single-blinded, prospective observational study of 106 patients presenting to two emergency departments (ED) with trauma to long bones showed, the sensitivity of POCUS to diagnose long bone fractures to be 90.2% (4/41, 95% CI: 76.9-97.3) and specificity to be 96.1% (4/102, 95% CI: 90.3-98.9). The study concluded that emergency physicians can accurately evaluate long bone fractures in the emergency department using POCUS.²¹ A systematic review and meta-analysis of thirty

studies on use of point of care ultrasound in long bone fractures were as follows: sensitivity 64.7%–100%, specificity 79.2%–100%. So POCUS would be regarded as an appropriate adjunct to plain radiographs for long bone fractures.²²

In our study small bones like metatarsal fractures were not observed. Some studies suggest that POCUS can be used in diagnosis of metatarsal fractures. Like this study, that showed POCUS to have sensitivity of 93%, specificity of 89%, PPV of 84% and NPV of 95% in detection of metatarsal fractures. This study concluded that POCUS can be used as an alternative to radiography in the emergency department.²³ So POCUS could be very useful tools for fracture diagnosis of other bones as well.

From observation of all these studies we can assert that point of care ultrasonography (POCUS) is a good method in evaluating long bone fractures in the emergency department. It has high accuracy, sensitivity and specificity and is safe and accessible. It can be very useful in emergency conditions and in situations where x-ray imaging is contraindicated or restricted.

Our study was done in emergency department in urban setting. Similar studies can be done in rural setting which would give more information on its reliability. Ultrasound guided diagnosis of fractures is useful in ED as well as rural settings. Portable USG device can be sent even in remote places. Health personnel can be easily trained to use the device. Ultrasound can be used in ED not only for fracture diagnosis but also for various other medical conditions. For this health professionals need to be properly trained and more studies need to be done to find out its reliability in various settings.

Conclusion

Our study shows that point of care ultrasonography (POCUS) has high sensitivity and specificity in the diagnosis of long bone fractures, compared to x-ray. So with proper

training and adequate practice by the emergency physicians, point of care of ultrasonography (POCUS) can be used in the emergency rooms, for rapid assessment and early detection of fractures of long bones in trauma cases and has advantages of being non-invasive, portable, cost-effective and does not cause ionizing radiation.

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Conflict of Interest

None

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Author Contribution

Concept, design, planning: DMJ, RM, DRH; Literature review: DMJ, SS; Data collection/analysis: DMJ, RM, SS; Draft manuscript: DMJ, SS; Revision of draft: DMJ, SS; Final manuscript: DMJ, SS.

Reference

1. Wu AM, Bisignano C, James SL, Abady GG, Abedi A, Abu-Gharbieh E, et al. Global, regional, and national burden of bone fractures in 204 countries and territories, 1990–2019: a systematic analysis from the Global Burden of Disease Study 2019. *The Lancet Healthy Longevity*. 2021;2(9):e580-92. | DOI | PubMed | Google Scholar | Full Text | Weblink |
2. Mishra BN, Jha A, Gupta Y. Epidemiology of Orthopaedic Admissions at A Teaching Hospital of Eastern Nepal. *Journal of Nobel Medical College*. 2017 Aug 22;6(1):56-62. | DOI | Google Scholar | Full Text | Weblink |
3. Aloudah AA, Almesned FA, Alkanan AA Jr, Alharbi T, Almesned F, Alkanan A Jr. Pattern of fractures among road traffic accident victims requiring hospitalization: single-institution experience in Saudi Arabia. *Cureus*. 2020;12(1). | DOI | PubMed | Google Scholar | Full Text | Weblink |
4. Abdolrazaghnejad A, Banaie M, Safdari M. Ultrasonography in emergency department; a diagnostic tool for better examination and decision-making. *Adv J Emerg Med*.

- 2018;2(1)e7. | [DOI](#) | [Google Scholar](#) | [Full Text](#) | [Weblink](#) |
5. Kozaci N, Ay MO, Avci M, Turhan S, Donertas E, Celik A, et al. The comparison of point-of-care ultrasonography and radiography in the diagnosis of tibia and fibula fractures. *Injury*. 2017;48(7):1628-35. | [DOI](#) | [PubMed](#) | [Google Scholar](#) | [Weblink](#) |
 6. Bahl A, Bagan M, Joseph S, Brackney A. Comparison of ultrasound and plain radiography for the detection of long-bone fractures. *J Emergencies, Trauma, and Shock*. 2018 Apr;11(2):115. | [DOI](#) | [Google Scholar](#) | [Weblink](#) |
 7. Frouzan A, Masoumi K, Delirroyfard A, Mazdaie B, Bagherzadegan E. Diagnostic accuracy of ultrasound in upper and lower extremity long bone fractures of emergency department trauma patients. *Electronic physician*. 2017 Aug;9(8):5092. | [DOI](#) | [Google Scholar](#) | [Full Text](#) | [Weblink](#) |
 8. Chen KC, Lin AC, Chong CF, Wang TL. An overview of point-of-care ultrasound for soft tissue and musculoskeletal applications in the emergency department. *Journal of intensive care*. 2016 Dec;4(1):1-1. | [DOI](#) | [PubMed](#) | [Google Scholar](#) | [Weblink](#) |
 9. Situ-LaCasse E, Grieger RW, Crabbe S, Waterbrook AL, Friedman L, Adhikari S. Utility of point-of-care musculoskeletal ultrasound in the evaluation of emergency department musculoskeletal pathology. *World Journal of Emergency Medicine*. 2018;9(4):262. | [DOI](#) | [PubMed](#) | [Full Text](#) |
 10. Kim J, Shakya PR, Choi S, Park JS, Tamrakar SR, Heo J, Kim WH. An evaluation of obstetric ultrasound education program in Nepal using the RE-AIM framework. *BMC Medical Education*. 2021 Dec;21(1):1-3. | [DOI](#) | [PubMed](#) | [Google Scholar](#) | [Full Text](#) | [Weblink](#) |
 11. Mytton JA, Bhatta S, Thorne M, Pant PR. Understanding the burden of injuries in Nepal: a systematic review of published studies. *Cogent Medicine*. 2019 Jan 1;6(1):1673654. | [DOI](#) | [Google Scholar](#) | [Full Text](#) | [Weblink](#) |
 12. Sonosite M Turbo, catalog, detail specification. | [Full Text](#) | [Weblink](#) |
 13. Lau BC, Robertson A, Motamedi D, Lee N. The validity and reliability of a pocket-sized ultrasound to diagnose distal radius fracture and assess quality of closed reduction. *The Journal of Hand Surgery*. 2017;42(6):420-7. | [DOI](#) | [PubMed](#) | [Google Scholar](#) | [Weblink](#) |
 14. Bozorgia F, Ms A, Khalilianc A. Accuracy of ultrasound for diagnosis of femur bone fractures in traumatic patients. *Journal of Clinical & Experimental Orthopaedics*. 2017. | [DOI](#) | [Google Scholar](#) | [Full Text](#) | [Weblink](#) |
 15. Caroselli C, Raffaldi I, Norbedo S, Parri N, Poma F, Blaina's M, Zaccaria E, Dib G, Fiorentino R, Longo D, Biban P. Accuracy of point-of-care ultrasound in detecting fractures in children: a validation study. *Ultrasound in Medicine & Biology*. 2021 Jan 1;47(1):68-75. | [DOI](#) | [PubMed](#) | [Google Scholar](#) | [Weblink](#) |
 16. Galleitebeitia Laka I, Samson F, Gorostiza I, Gonzalez A, Gonzalez C. The utility of clinical ultrasonography in identifying distal forearm fractures in the pediatric emergency department. *European Journal of Emergency Medicine*. 2019 Apr 1;26(2):118-22. | [DOI](#) | [PubMed](#) | [Google Scholar](#) | [Weblink](#) |
 17. Farahmand S, Arshadi A, Bagheri-Hariri S, Shahriarian S, Arbab M, Sedaghat M. Extremity fracture diagnosis using bedside ultrasound in pediatric trauma patients referring to emergency department; a diagnostic study. *International Journal of Pediatrics*. 2017 Oct 1;5(10):5959-64. | [DOI](#) | [Google Scholar](#) | [Full Text](#) | [Weblink](#) |
 18. Eckert K, Ackermann O, Schweiger B, Radeloff E, Liedgens P. Sonographic diagnosis of metaphyseal forearm fractures in children: a safe and applicable alternative to standard x-rays. *Pediatric emergency care*. 2012 Sep 1;28(9):851-4. | [DOI](#) | [PubMed](#) | [Google Scholar](#) | [Weblink](#) |
 19. Patel DD, Blumberg SM, Crain EF. The utility of bedside ultrasonography in identifying fractures and guiding fracture reduction in children. *Pediatr Emerg Care*. 2009 Apr;25(4):221-25. | [DOI](#) | [Google Scholar](#) | [Weblink](#) |
 20. Avci M, Kozaci N, Tulubas G, Caliskan G, Yuksel A, Karaca A, et al. Comparison of point-of-care ultrasonography and radiography in the diagnosis of long-bone fractures. *Medicina*. 2019 Jul 9;55(7):355. | [DOI](#) | [PubMed](#) | [Google Scholar](#) | [Full Text](#) | [Weblink](#) |
 21. Waterbrook AL, Adhikari S, Stolz U, Adrion C. The accuracy of point-of-care ultrasound to diagnose long bone fractures in the ED. *The American journal of emergency medicine*. 2013 Sep 1;31(9):1352-6. | [DOI](#) | [PubMed](#) | [Google Scholar](#) | [Weblink](#) |
 22. Chartier LB, Bosco L, Lapointe-Shaw L, Chenkin J. Use of point-of-care ultrasound in long bone fractures: a systematic review and meta-analysis. *Canadian Journal of Emergency Medicine*. 2017 Mar;19(2):131-42. | [DOI](#) | [PubMed](#) | [Google Scholar](#) | [Weblink](#) |
 23. Kozaci N, Ay MO, Avci M, Beydilli I, Turhan S, Donertas E, Ararat E. The comparison of radiography and point-of-care ultrasonography in the diagnosis and management of metatarsal fractures. *Injury*. 2017 Feb 1;48(2):542-7. | [DOI](#) | [PubMed](#) | [Google Scholar](#) | [Weblink](#) |