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Original Article

Accuracy and Reliability of Cortical Buckling or Bulging: A Reliable Indicator of Ultrasound in Diagnosing Buckle or Torus Fracture of Long Bones in Children

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ABSTRACT

Buckle fractures in children are non-displaced, incomplete compression fractures resulting in bulging or buckling of the bone cortex without disruption. **Objective:** To assess the diagnostic accuracy of ultrasound and the reliability of cortical buckling or bulging as an indicator of ultrasound in diagnosing buckle fractures of long bones in children while using radiography as the reference standard. **Methods:** A cross-sectional study conducted at the Radiology Department of the Trauma Centre of Saidu Group of Teaching Hospitals, Swat, from May 2022 to January 2023. The sample size consisted of 148 patients aged 0-18 years with 204 clinically suspected long bone fractures. Because specific clinical markers for isolating buckle fractures are lacking, a general population of patients with long bone injuries was considered. Sonographic scans of the suspected fractures were performed followed by the plain radiography and images of buckle fractures were saved on both modalities for comparison. **Results:** Sonographic buckling or bulging was found in 24 out of 25 total buckle fractures. One sonographic buckle fracture was also missed radiographically. The diagnostic accuracy of ultrasound in diagnosing buckle fractures was found 98.53% with a sensitivity and specificity of 96% and 99.10% respectively. PPV and NPV of ultrasound were found 96% and 99.10% respectively. **Conclusions:** Ultrasound can be used as the initial screening modality for diagnosing buckle fractures in long bones in children due to its high diagnostic accuracy and the reliability of cortical buckling or bulging as a sonographic indicator.

INTRODUCTION

Buckle fractures, also known as Torus fractures, are a form of non-displaced, incomplete compression fracture in children that causes buckling or bulging of the bone cortex without disruption [1-3], and are usually characterized by a kink within the bone [4]. Buckle fractures affect 1 in every 25 children and account for 50% of pediatric wrist fractures [5]. Although they can occur at the distal femur and tibia, distal radius buckle fractures are the most common type of pediatric fracture and account for the highest number of fracture visits to the Emergency Department in the United States. They are most commonly caused by the low energy falls on an outstretched hand [6]. Patients with buckle fractures are typically discharged with a splint or immobilization in plaster of Paris, either back-slab or full cast, and do not require further imaging or follow-up [7, 8]. Buckle fractures are mainly diagnosed by

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plain radiography but it carries a risk of radiation hazards produced by ionizing radiation in x-rays especially in children who are about 10 times more radiosensitive than adults due to their smaller body size and increased mitotic activity. Although a small quantity of radiation is used but the radiation dose is cumulative [7-9]. On the other hand; a large number of un-necessary x-rays are used for suspected fractures as to one study, 82.8% of the x-rays conducted only in children for suspected fractures, showed no fracture [11]. MSK ultrasound can be an alternate radiation free imaging modality for screening buckle fractures in children as it is safe, fast, portable, painless, dynamic, cost efficient and more sensitive than plain radiography [6, 12-14]. The purpose of this study was to assess the diagnostic accuracy of ultrasound and the reliability of cortical buckling or bulging as an indicator of ultrasound in diagnosing buckle fractures of long bones in children while using radiography as the reference standard, in order to reduce the risks and burden of unnecessary x-rays on children and the health care system.

METHODS

This was an analytical cross-sectional study conducted at the Radiology Department of the Trauma Centre, Saidu Group of Teaching Hospitals in Swat, from May 2022 to January 2023. Since there are no specific clinical markers for isolating buckle fractures, patients with long bone injuries were selected as the study population. A non-probability purposive sampling technique was employed. The inclusion criteria consisted of clinically suspected long bone fractures presenting with symptoms such as pain, swelling, tenderness, restricted or impaired motion of the affected extremity, and ecchymosis. A total of 188 patients were selected with a 95% confidence interval and an 8% margin of error. The sample size was determined based on an anticipated ultrasound sensitivity of 90% and a prevalence of long bone fractures of 28.7% [15, 16]. Exclusion criteria encompassed open fractures, soft tissue lesions at the fracture site, neurovascular injuries, life-threatening conditions, cases with unstable vital signs, severe pain during ultrasound scanning, re-fractures, presence of orthopedic hardware, and dislocation along with the fracture. Clinically suspected patients were referred to the Radiology Department of the Trauma Center for radiography following confirmation by an orthopedic physician. Prior to conducting the sonographic and radiographic examinations, parents or guardians were informed about the study and written informed consent was obtained. The patients were scanned in a position comfortable to them. Stable children were mostly scanned in the laps of their parents/guardians. Unstable patients were scanned in their stretchers and wheel chairs who were unable to be shifted to the patient's examination couch. Esaote MyLab sigma ultrasound machine with a linear probe of having frequency 10-15MHz was used for ultrasound scans. The scan was started by putting the transducer on the lateral side of the bone to assess the depth and location of the bone suspected for fracture after applying sufficient amount of gel for good coupling. After finding the hyperechoic cortex of the bone (Figure 1).

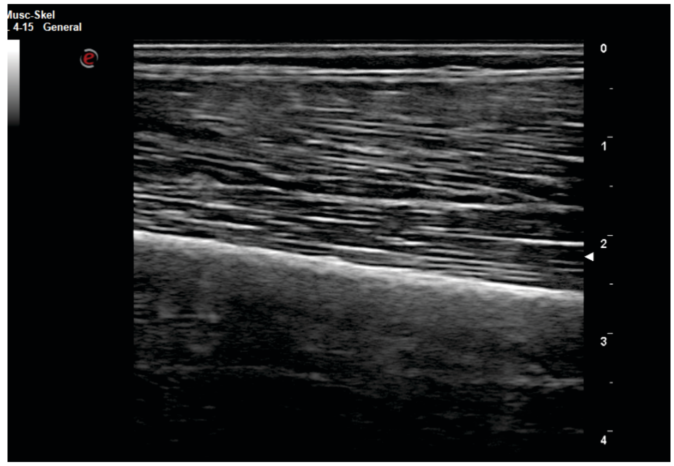
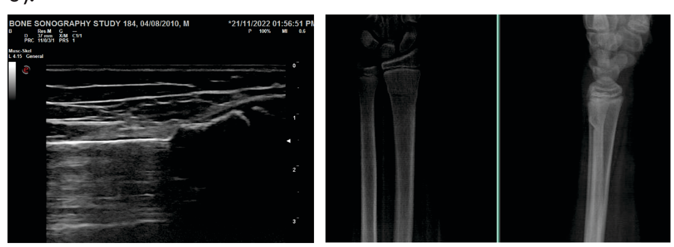


Figure 1: Normal hyperechoic bone cortex

The transducer was placed longitudinally to scan the entire bone in all directions and sides i.e. anteriorly, posteriorly, medially and laterally to find any cortical buckling or bulging in the bone for assessing the buckle fracture (Figures 2 and 3).



A B

Figure 2: (A) cortical buckling, **(B)** X-Ray of the same patient

A B

Figure 3: (A) cortical bulging, **(B)** X-Ray of the same patient

In case of two adjacent bones like radius and ulna, additional medial and lateral oblique views were also taken for both anterior and posterior sides. The sonographic findings obtained were recorded in the proforma. Presence or absence of buckle fracture was declared

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sonographically and the images and video clips were saved for further use. The patient was then sent for radiographic evaluation. Two radiographic projections i.e. AP and lateral were obtained using x-ray machine Konica Minolta AeroDR X70, a 1000mA machine with digital radiography system. Buckle fractures were assessed by finding a kink in the cortex of the bone. Radiographic findings were noted on the proforma. Presence or absence of buckle fracture was declared radiographically and the images were saved for further use. Finally, images of both modalities were shown to the radiologist for the confirmation of the buckle fracture and the patient was then referred to the orthopedic department for treatment. Out of 188, only 148 patients were within the age group of 1-18 years, and were included in the study, comprising 204 suspected fractured bones. Data were analyzed using SPSS software version 27.0. In the data sheet, the sonographic and radiographic fractures were presented as fracture present or absent. The patient's demography, bones fractured/affected, the sonographic marker of cortical buckling and radiographic buckling were plotted separately for their presence and absence. Radiography was considered as the reference standard for comparison. The diagnostic accuracy of ultrasound was measured in terms of sensitivity, specificity, positive predictive value and negative predictive values.

RESULTS

A total of 148 patients with 204 suspected fractures ranging in age from 1 to 18 years were assessed out of which fracture was diagnosed in 136 bones of 107 patients. There were a total 25 buckle fractures out of which 24 were diagnosed sonographically for which cortical buckling or bulging was also present while one was missed. There was also a sonographic buckle fracture which was missed radiographically (Table 1).

Table 1: Comparison between sonographic and radiographic diagnosis of buckle fractures

Sonographic fracture (cortical buckling)	Radiographic fracture		Total
	Present	Absent	
Present	24	1	25
Absent	1	110	111
Total	25	111	136

Buckle fractures accounted for 18.38% of all the fractures in children. Buckle fractures were more common in children aged 6-11 years (40%) than in young teens aged 12-13 years (28%), (Figure 4).

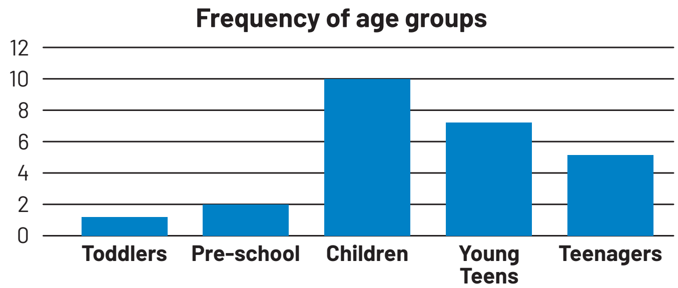


Figure 4: Frequency of Age groups in buckle fractures

72% of the fractured patients were male and 28% were female (Figure 5).

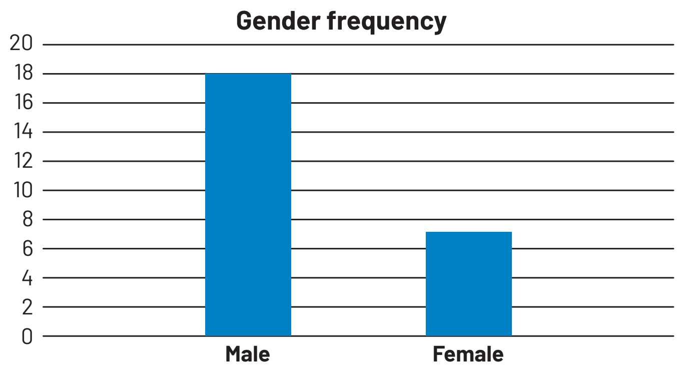
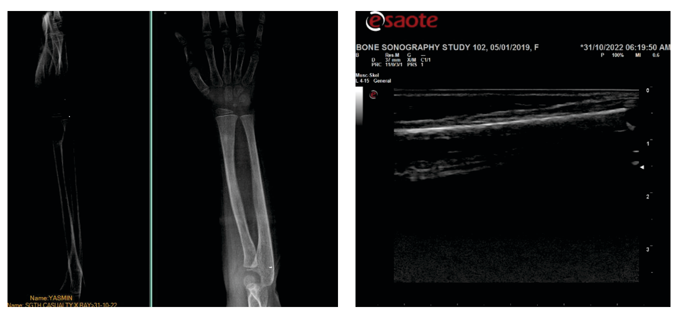


Figure 5: Gender Frequency



A B

Figure 6 A: a kink is present in the radiograph **B:** no sonographic buckling

84% of the buckle fractures occurred in the radius followed by the ulna with a percentage of 12% (Table 2).

Table 2: Frequency of bones fractured

Bone fractured	Frequency (%)
Radius	21(84)
Ulna	3(12)
Tibia	1(4)
Total	25(100)

The most common cause of injury was a fall with a frequency of 84% followed by RTA at a frequency of 16% (Table 3).

Table 3: Frequency of causes of fracture

Cause of injury	Frequency (%)
Fall	21(84)
RTA	4(16)
Total	25(100)

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The most prominent clinical signs showing a buckle fracture were swelling and tenderness (table 4).

Table 4: Frequency of clinical signs

Clinical signs	Mild	Moderate	Severe
Pain	15(60)	7(28)	3(12)
Swelling	5(20)	8(32)	12(48)
Tenderness	4(16)	10(40)	11(44)
Ecchymosis	15(60)	6(22)	4(16)
Motion of the bone	-	19(76)	6(24)

Hematoma was a reliable indirect sign of buckle fracture present in 100% of cases (Table 5).

Table 5: Frequency of hematoma formation

Hematoma	Frequency (%)
Present	25(100)
Total	25(100)

Ultrasound showed a good diagnostic accuracy of 98.53% in diagnosing buckle fracture by its specific indicator of cortical buckling or bulging. Sensitivity and specificity of ultrasound in diagnosing buckle fracture were 96% and 99.10% respectively. PPV and NPV were also 96% and 99.10% respectively (Table 6).

Table 6: Diagnostic accuracy of ultrasound in buckle fractures

Statistics	Value	95% CI
Sensitivity	96%	79.65 to 99.90%
Specificity	99.10%	95.08 to 99.98%
Positive predictive value	96%	79.65 to 99.90%
Negative predictive value	99.10%	95.08 to 99.98%
Accuracy	98.53%	94.79 to 99.82%

DISCUSSION

Buckle fracture is a common long-bone fracture in children, and radiography is commonly used to diagnose it, posing radiation risks. The radiation dose of children is up to ten times that of adults. Therefore, there should be another imaging modality that is radiation free, as a large number of unnecessary x-rays are utilized for suspected fractures, with relatively few x-rays showing fracture. This study was designed to assess the diagnostic accuracy of ultrasound and the reliability of cortical buckling or bulging as a sonographic indicator of ultrasound for diagnosing buckle fractures in children. Studies on this particular topic are quite rare. Our study revealed that tenderness and swelling are reliable clinical signs of buckle or Torus fractures, which is supported by a recent study conducted by Gonzalez *et al.*, in 2022. Our study reveals that fall is the common cause of buckle fractures which is again similar to the finding of Gonzalez. In our investigation, ultrasonography found 24 of the 25 buckle fractures, which is quite comparable to the findings of Pountos *et al.*, in which all of the radiographic buckle fractures were also diagnosed sonographically [6, 7]. One fracture that ultrasound missed was due to the possibility that fracture had healed as all of the clinical symptoms were mild (figure 6). The sensitivity and specificity of ultrasonography in our investigation were 96% and 99.10%, respectively, which are comparable to the findings of Poonai *et al.*, conducted in 2017 in which the sensitivity and specificity of ultrasound were 94.7% and 93.5% respectively [17]. Specificity of our study which is 99.10% is comparable to that of the study of Kozaici *et al.*, conducted in 2014 in which the sensitivity and specificity of ultrasound in buckle or torus fractures were 78% and 98% respectively [12]. Subperiosteal hematoma was found in 100% of cases in our study which is supported by the study of Al-Allaf and Al-Dubouni conducted in 2008 showing 100% hematoma associated with fractures [18-20].

CONCLUSIONS

Our study revealed that ultrasound has a good diagnostic accuracy of 98.53% with sensitivity and specificity of 96% and 99.10% respectively in diagnosing buckle or torus fractures in long bones in children. Cortical buckling or bulging seen in buckle fractures is a reliable indicator of ultrasound as almost all of the cases with such feature were also diagnosed radiographically.

Authors Contribution

Conceptualization: AAK
Methodology: AAK, RB
Formal analysis: RZ, BAK, BR, DKM
Writing-review and editing: RZ, IAK, AAK

All authors have read and agreed to the published version of the manuscript.

Conflicts of Interest

The authors declare no conflict of interest.

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REFERENCES

[1] Patel DS, Statuta SM, Ahmed N. Common Fractures of the Radius and Ulna. American Family Physician. 2021 Mar; 103(6): 345-54.
[2] Ling SN and Cleary AJ. Are unnecessary serial radiographs being ordered in children with distal radius buckle fractures? Radiology Research and Practice. 2018 Mar; 2018: 1-4. doi: 10.1155/2018/5143639.
[3] Fortis A, Vergados N, Pontiki E. Ultrasonography: An alternative imaging modality in diagnosing greenstick fractures. Early experience in a county hospital. Acta Orthopaedica Et Traumatologica Hellenica. 2020 Feb; 68(2): 57-60.
[4] Asokan A and Kheir N. Pediatric torus buckle fracture. StatPearls Publishing, Treasure Island (FL).

DOI: https://doi.org/10.54393/pjhs.v4i06.852

2022 Aug.
[5] Ben-Yakov M and Boutis K. Buckle fractures of the distal radius in children. Canadian Medical Association Journal. 2016 Mar; 188(7): 527. doi: 10.1503/cmaj.151239.
[6] Gonzalez N, Lucas JM, Winegar A, Den Haese J, Danahy P, Gonzalez NM, *et al*. A Review of Pediatric Distal Radius Buckle Fractures and the Current Understanding of Angled Buckle Fractures. Cureus. 2022 May; 14(5): 1-7. doi: 10.7759/cureus.24943.
[7] Pountos I, Clegg J, Siddiqui A. Diagnosis and treatment of greenstick and torus fractures of the distal radius in children: a prospective randomised single blind study. Journal of Children's Orthopaedics. 2010 Aug; 4(4): 321-6. doi: 10.1007/s11832-010-0269-3.
[8] Snelling PJ, Keijzers G, Byrnes J, Bade D, George S, Moore M, *et al*. Bedside Ultrasound Conducted in Kids with distal upper Limb fractures in the Emergency Department (BUCKLED): a protocol for an open-label non-inferiority diagnostic randomised controlled trial. Trials. 2021 Dec; 22(1): 1-2. doi: 10.1186/s13063-021-05239-z.
[9] Wang CC, Linden KL, Otero HJ. Sonographic Evaluation of Fractures in Children. Journal of Diagnostic Medical Sonography. 2017 Jan; 33(3): 200–7. doi: 10.1177/8756479316688897.
[10] de Borja C, Watkins R, Woolridge T. Common Ultrasound Applications for Pediatric Musculoskeletal Conditions. Current Reviews in Musculoskeletal Medicine. 2022 Dec; 15(6): 447-55. doi: 10.1007/s12178-022-09788-x.
[11] Hübner U, Schlicht W, Outzen S, Barthel M, Halsband H. Ultrasound in the diagnosis of fractures in children. Journal of Bone and Joint Surgery British. 2000 Nov; 82(8): 1170-3. doi: 10.1302/0301-620x.82b8.10087.
[12] Kozaci N, Ay MO, Akcimen M, Turhan G, Sasmaz I, Turhan S, *et al*. Evaluation of the effectiveness of bedside point-of-care ultrasound in the diagnosis and management of distal radius fractures. The American Journal of Emergency Medicine. 2015 Jan; 33(1): 67-71. doi: 10.1016/j.ajem.2014.10.022.
[13] Saul T. Point-of-care ultrasound in the diagnosis of upper extremity fracture-dislocation. A pictorial essay. Medical Ultrasonography. 2013 Sep; 15(3): 230–6. doi: 10.11152/mu.2013.2066.153.ts1ln2.
[14] Eckert K, Ackermann O, Schweiger B, Radeloff E, Liedgens P. Ultrasound as a viable alternative to standard X-rays for the diagnosis of distal forearm fractures in children. Zeitschrift fur Orthopadie und Unfallchirurgie. 2012 Aug; 150(4): 409-14.
[15] O'Brien AJ and Moussa MA. Using ultrasound to diagnose long bone fractures. JAAPA. 2020 Feb; 33(2): 33-7. doi: 10.1097/01.JAA.0000651736. 0253 7.ef.
[16] Dkhar I, Hazra D, Madhiyazhagan M, Joseph JV, Abhilash KP. A retrospective study on the profile of long bone injuries in trauma patients presenting to emergency department. Current Medical Issues. 2019 Jul; 17(3): 60-5. doi: 10.4103/cmi.cmi_35_19.
[17] Poonai N, Myslik F, Joubert G, Fan J, Misir A, Istasy V, *et al*. Point-of-care ultrasound for nonangulated distal forearm fractures in children: test performance characteristics and patient-centered outcomes. Academic Emergency Medicine. 2017 May; 24(5): 607-16. doi: 10.1111/acem.13146.
[18] Al-Allaf HK and Al-Dubouni FA. Ultrasound imaging of undisplaced partial forearm fractures in children. Annals of the College of Medicine Vol. 2008; 34(1): 1-7. doi: 10.33899/mmed.2008.8946.
[19] Martinoli C, Valle M, Malattia C, Beatrice Damasio M, Tagliafico A. Paediatric musculoskeletal US beyond the hip joint. Pediatric Radiology. 2011 May; 41: 113-24. doi: 10.1007/s00247-011-2037-z.
[20] Norris TG. Pediatric skeletal trauma. Radiologic Technology. 2001 Mar; 72(4): 345-.